



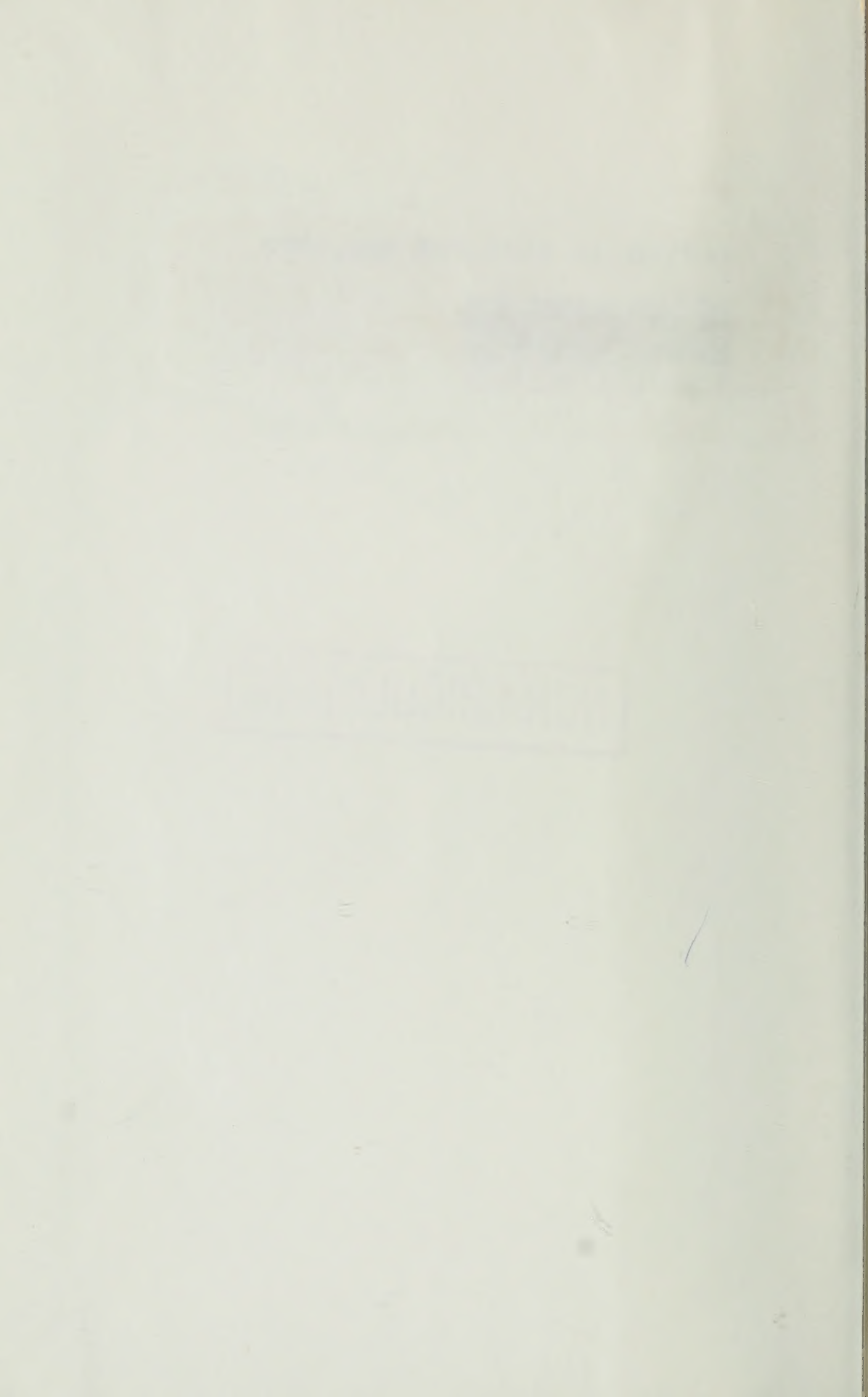
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NON-CIRCULATING



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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

COMMON INSECTS AFFECTING FRUIT-TREES

By C. J. S. BETHUNE, M.A., D.C.L., PROFESSOR OF ENTOMOLOGY,

AND

FUNGUS DISEASES AFFECTING FRUIT-TREES

By TENNYSON D. JARVIS, B.S.A., LECTURER IN ENTOMOLOGY.

[In June last (1907) a Bulletin on "Common Insects Affecting Fruit-trees" was published and widely distributed. Recently it was found that the edition was exhausted, and consequently it has been deemed advisable to reissue the Bulletin with the addition of some account of the most common fungus diseases that affect fruit-trees and that are likely to cause trouble and loss to the fruit-grower.]

INTRODUCTION.

To treat of all the insects affecting fruit-trees in Ontario would be manifestly impossible within the limits of space assigned to a Bulletin. In the following pages, therefore, reference will be made only to those species that are commonly met with, and that are sufficiently abundant year after year to require attention on the part of the fruit-grower. The remedies prescribed are those that have been found by repeated experiments to be the most effective. Much depends, however, upon the care which is exercised in making up and applying the various spraying mixtures, the time when the work is done, and the methods of cultivation which are employed. It is of little use to attempt to kill some insects on a tree or bush, if suitable and convenient hiding places are left for them close by, or if wild plants of a similar character are allowed to serve as breeding places without molestation. Wild Cherry-trees, for instance, may often be seen covered with the webs of the Tent-caterpillar in the near neighborhood of orchards and no notice whatever is taken of them, while the fruit-grower labors to clear his trees and wonders that after all his efforts a fresh attack occurs each year.

The Mountain Ash, a European tree cultivated for its beauty, is often to be found near gardens and orchards. Being closely akin, botanically, to the Apple, it is attacked by scale and other dangerous insects, and is often a convenient and unsuspected breeding place for many pests of the orchard. It should receive the same treatment as the fruit-

trees or else be removed altogether. The Hawthorns are another class of trees akin to the Apple, and serve in a similar manner as breeding places for orchard pests; none should be suffered to grow near the fruit-trees. Both the Wild Cherry and the Wild Plum are also particularly dangerous from the serious fungus diseases to which they are liable, such as the Black-knot, Plum-pockets, Brown-rot and Shot-hole fungus, and which soon spread from them to healthy fruit-trees; the latter also harbors the Plum Curculio.

Clean cultivation is of quite as much importance as the application of remedies. Twigs and branches cut off when pruning should be burnt, all fallen fruit should be gathered up and destroyed, no rubbish of any kind should be permitted to remain in the orchard or garden. The trees themselves should be kept clean by scraping off all rough loose bark. All this should be done in order to leave no hiding place or shelter for insects during their chrysalis or pupal stage, and to compel them to seek elsewhere for winter quarters or perish. Spring and autumn, when work is not very pressing, are good times for a general cleaning up, and tree scraping may be done at any time during the winter when the weather happens to be mild. But the gathering up of fallen fruit should be done daily in order to leave no time for the Codling-worm, Apple-maggot, or other pest to escape.

The practice of clean cultivation is of prime importance also in checking or warding off the attacks of fungus diseases. The microscopic spores by which these diseases are spread are harbored to a large extent by fallen and rotting fruit, withered leaves, brushwood left from pruning, and rubbish of all sorts that may gather round the trees. The removal and disposal by burning or burying of all such waste matter in the autumn, or during the winter, will get rid of the hibernating forms of a large number of our worst fungus diseases as well as insect enemies.

Fruit-trees, especially the more delicate sorts, are often injured during the winter by severe frosts suddenly following a period of mild weather; these injurious effects may not be noticeable, but they are frequently sufficient to impair the vitality of the tree and to render it liable to the attacks of cankers and other fungus diseases which in a healthy condition it would be able to resist. Furthermore, a tree may be planted in a soil or in a situation which is unsuited to that particular variety and may therefore fail to become sufficiently robust to resist diseases which in proper conditions it would entirely escape. These are matters too often overlooked by the fruit-grower and he is in consequence at a loss to account for the failure of his trees, which may be due to causes of this kind.

In the warfare against noxious insects Nature provides an army of assistants which in a natural condition of things would keep the destructive hordes in check, but where all vegetation is swept away to make room for a few cultivated varieties, the balance is upset and our friends

are insufficient for the task, though they afford material help. All our insectivorous birds should be protected and encouraged, especially the woodpeckers and chickadees, which remain with us all winter. The former destroy an immense number of borers, codling-worms, etc., and the latter pick out many minute insects that spend the winter about the buds and in crevices in the bark of trees. Toads, snakes, and skunks, though generally regarded with aversion, are really most useful creatures, and assist very largely in reducing the numbers of destructive insects.

INSECTS AFFECTING THE APPLE.

THE CODLING WORM (*Carpocapsa pomonella*), Figs. 1 and 2. The insect that causes the greatest amount of annual loss to the Ontario fruit-grower is, no doubt, the Codling Moth (*Carpocapsa pomonella*), and yet probably not one orchardist in fifty has ever seen the moth itself. It is very small, flies only at night, is not attracted by either lights or sweets, and consequently can rarely be obtained except by breeding it from the worm. Everyone, however, is familiar with the worm or caterpillar which feeds in the interior of the fruit. The moth lays her scale-like eggs about the time the trees are in bloom on the leaves, stem or skin of the young apple. In a few days the larva is hatched out and proceeds to burrow into the fruit, usually in the cavity at the calyx end.

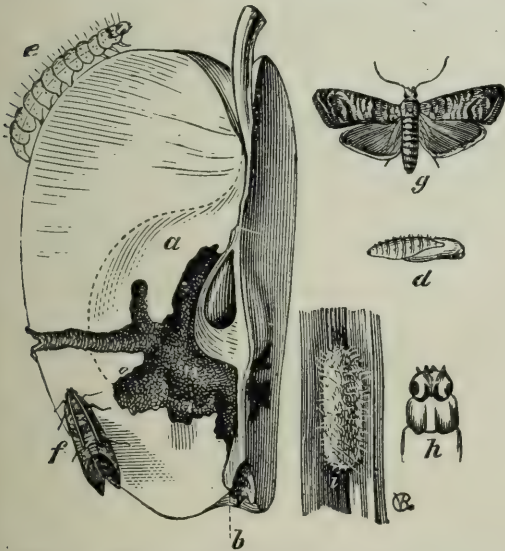


Fig. 1. The Codling Moth and its work, showing the different stages.

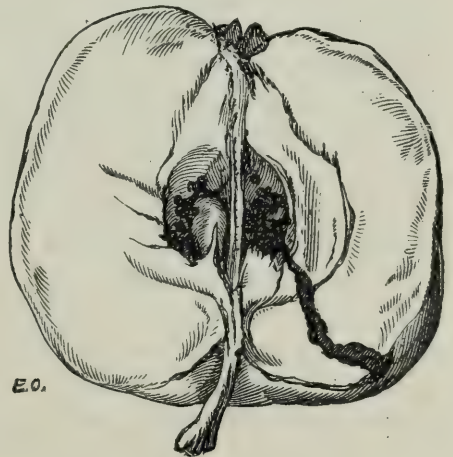


Fig. 2. Apple injured by the burrows of a Codling Worm.

After a time the infested apple falls to the ground, the worm emerges, and usually finds its way to the tree, where it forms its cocoon under the bark or other shelter. Throughout the southern counties of Ontario there are two broods in the year, but east of Toronto and north of that latitude there is usually but one brood, though a small percentage may

develop early and produce a second. This is a point in the life-history of the insect of very great importance, and every fruit-grower should endeavor to find out whether there are two or only one brood in his own locality.

Where there is but one brood the remedy for the insect is comparatively easy. It consists in spraying the trees with Paris green (combined with Bordeaux mixture for the purpose of warding off fungus diseases) just after the blossoms have fallen and again a week later. This will ensure the destruction by the poison of the majority of the young larvæ. Most of those that escape can be got rid of by gathering up the fallen fruit and feeding it to pigs or burying it deeply in the ground. An easier plan is to let the pigs have the run of the orchard, and they will make away with the fallen fruit themselves.

In all that section of the country where there are two broods it is necessary to adopt further measures in addition to the above. One plan is to spray the trees again towards the end of June and at about ten days' interval till the end of July. A more effective remedy is to bandage the trunks of the trees with burlap, sacking, or other coarse material. The bands should be about eight or ten inches wide and attached to the tree by a string tied tightly around the middle, leaving the top and bottom loose, and fastened to a nail. The worms will go to these bandages as a convenient shelter under which to form their cocoons, and can readily be destroyed. It is necessary to remove the bandages at least as often as every ten days; the larvæ attached to them may be killed by passing the bandages through a clothes-wringer carried on a wheelbarrow. Many, however, burrow into the bark to make their chrysalids, and require to be got rid of by scraping with a wire brush. By adopting these measures the second brood of worms, which is by far the most injurious to the fruit, will be reduced to a minimum. Careful spraying in the spring, continued year after year, will so effectually get rid of the insect that very few will survive to form a second brood, and the fruit-grower may hope to be relieved of the labor and expense of the summer campaign.

A parasite of the Codling-worm has recently been introduced into California, and is apparently doing good work by reducing the numbers of the insect. It is too soon yet to form a definite opinion regarding its permanent usefulness, and experiments will require to be made in order to prove its ability to thrive in the climate of Ontario.

THE APPLE-MAGGOT (*Rhagoletis* [*Trypeta*] *pomonella*). This insect attacks the fruit by burrowing in all directions through the flesh which it feeds upon, and leaving brown channels—thus rendering the fruit perfectly valueless. Fortunately it has so far been found in few localities in Ontario, but it is quite common in New York and New England States, and may at any time spread over this country.

The parent is a two-winged fly, somewhat smaller than a house-fly, black in color, with a yellowish head and legs, green eyes and transparent

wings crossed with four irregular black bands. The eggs are laid in early summer beneath the skin of the fruit, and the young maggots which hatch from them become full-grown in about six weeks. The fruit then drops prematurely to the ground, and the maggots soon bury themselves in the soil, where they form their puparia and remain till the following spring. (Fig. 3.)

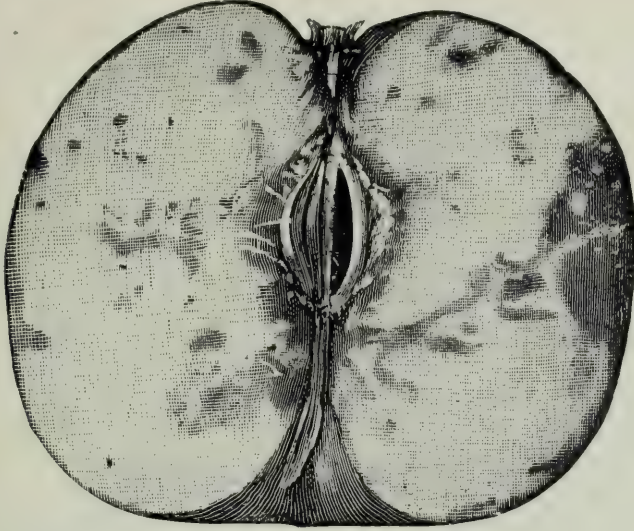


Fig. 3. Fruit injured by the Apple Maggot (*Trypeta*).

From the habits of the insect it is evident that it cannot be reached by any poison; the only remedy for it that has been found effective is the immediate destruction of the fallen fruit in order to prevent the maggots escaping into the ground. This may most easily be done by keeping a sufficient number of pigs or sheep in the orchard to devour the fruit as fast as it falls. If this should not be practicable, the work must be performed by hand, and the collected fruit fed to stock or otherwise destroyed. All refuse or injured apples in storage should also be similarly disposed of in order to prevent the flies from coming to maturity.

TENT-CATERPILLARS (*Malacosoma Americana* and *disstria*), Figs. 4-8. As soon as the buds open and the young leaves begin to appear, there are hatched out from the eggs in which they have spent the winter, tiny caterpillars which form a web in a convenient fork of the branch for their shelter and concealment when at rest, and from which they travel up and down, leaving a thread of silk as they go, and devouring the tender foliage, completely stripping all leaves from the bough. These are called Tent-caterpillars, and are represented in all stages in the accompanying figures. They are easily disposed of by going round the trees in the early morning, or towards evening, and clearing out the webs with the enclosed colony of worms. A simple plan is to tie a rag around the end of a long rod, insert it into the nest, and by revolving the stick, wind up the whole web with its inmates. This can be removed and trodden under foot, and the operation repeated till there are none left.

The location of the webs can be learnt while carrying on the spraying for the Codling-worms. During the warmer hours of the day the caterpillars are scattered over the limb, feeding upon the foliage, and therefore it is necessary to attack them when they are all at home in their tent. If they are allowed to grow big, they distribute themselves over the tree, and can only be destroyed by a liberal spray of Paris green or other poison.

The second species, the Forest Tent-caterpillar (*M. disstria*), attacks forest and shade trees of various kinds, and sometimes also invades the

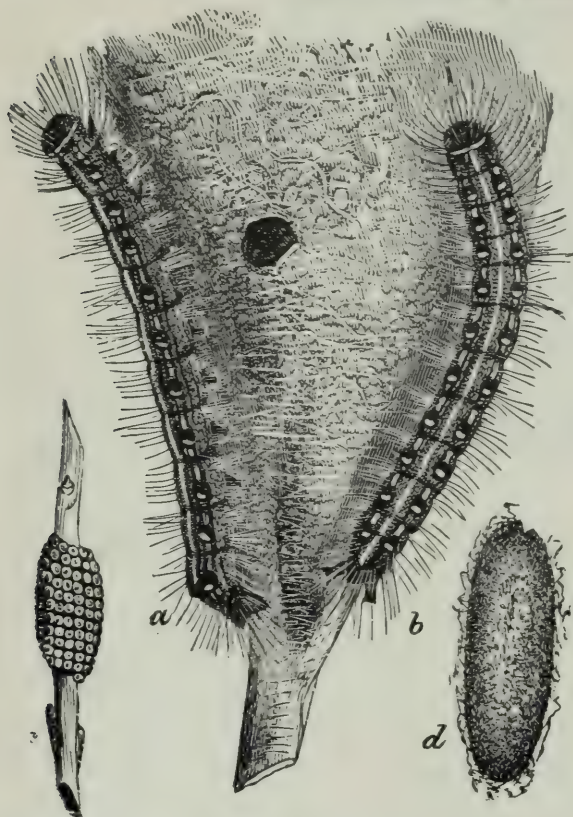


Fig. 4. Apple Tree Tent-caterpillars on their web; c, egg-bracelet; d, cocoon.



Fig. 5. Tent-caterpillar: Male Moth.



Fig. 6. Female Moth.



Fig. 7. Forest Tent-caterpillar: Moth and eggs.

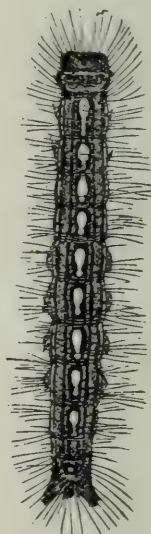


Fig. 8. Forest Tent-caterpillar.

orchard and garden. As the larvæ do not live in a "tent," the method mentioned above cannot be employed, but they have a habit of assembling in masses on a carpet of silk on a trunk or limb of the tree they infest, and can then be crushed with a spade or other convenient instrument. Paris green may also be employed.

The eggs of both species are laid in broad rings or bracelets on the twigs of the trees they infest. With a little experience they can be seen on apple and other trees during the winter when the leaves are off. If removed and burnt at that time much further trouble will be saved.

The caterpillars of the two species may be distinguished from each other by the continuous white stripe down the middle of the back in the case of the "American," and the series of spots in the same position on the "Forest" variety. When fully grown the caterpillars wander away from the trees and form their cocoons in any nearby shelter, such as a fence, bits of board, chips or other rubbish. The cocoon is made of whitish silk, within which is a sulphur-like powder producing a yellowish color.

The moths are thick-bodied fluffy creatures, of a dull reddish-brown color; the fore-wings of the "American" species are crossed by two oblique parallel whitish lines enclosing a pale space, while those of the "Forest" have similar lines of a dark brown color and enclosing a dark space. In other respects they are very much alike. They appear early in July, and flying at night are attracted by lights and come into houses, where they dash about, and sometimes cause much annoyance by getting into the cream-jug or butter-dish, and covering the contents with their fluffy scales. The eggs are laid at this time of year, and remain on the trees till the following spring. Usually these insects are abundant for only a few years at a time; there is then a period of freedom from them, caused no doubt by the attacks of parasites and disease.

THE FALL WEB-WORM (*Hyphantria textor*). Late in summer, webs may again be found upon the fruit-trees, larger in size and darker in color than those of the Tent-caterpillar. These are filled with a numerous colony of hairy caterpillars which cover the whole of the leaves where they are feeding with a loosely woven silken web, and live within it at all times. These webs become very unsightly from being filled with the skeletons of leaves and the cast-off skins and excrement of the inmates. As they are very conspicuous there can be no excuse for leaving them on the trees. It is easy to get rid of them by winding them up with a rod in the same manner as the "tents" of the preceding species, or when large by cutting off the affected branch; the colony should be disposed of by crushing under foot or burning, as may be convenient.

The parent moth is pure white without spots on the wings, or sometimes more or less spotted with black. It appears in early summer, having spent the winter in a silken cocoon, and lays its eggs in patches on the under side of leaves, from which the caterpillars emerge in July or August and proceed to form their webs. These worms vary to some

extent in color and are covered with long straight hairs arranged in tufts along the body; when full grown they are about an inch in length.

The attacks of these insects are by no means confined to fruit-trees; their webs are quite as abundant on ash, willow, and many other trees.

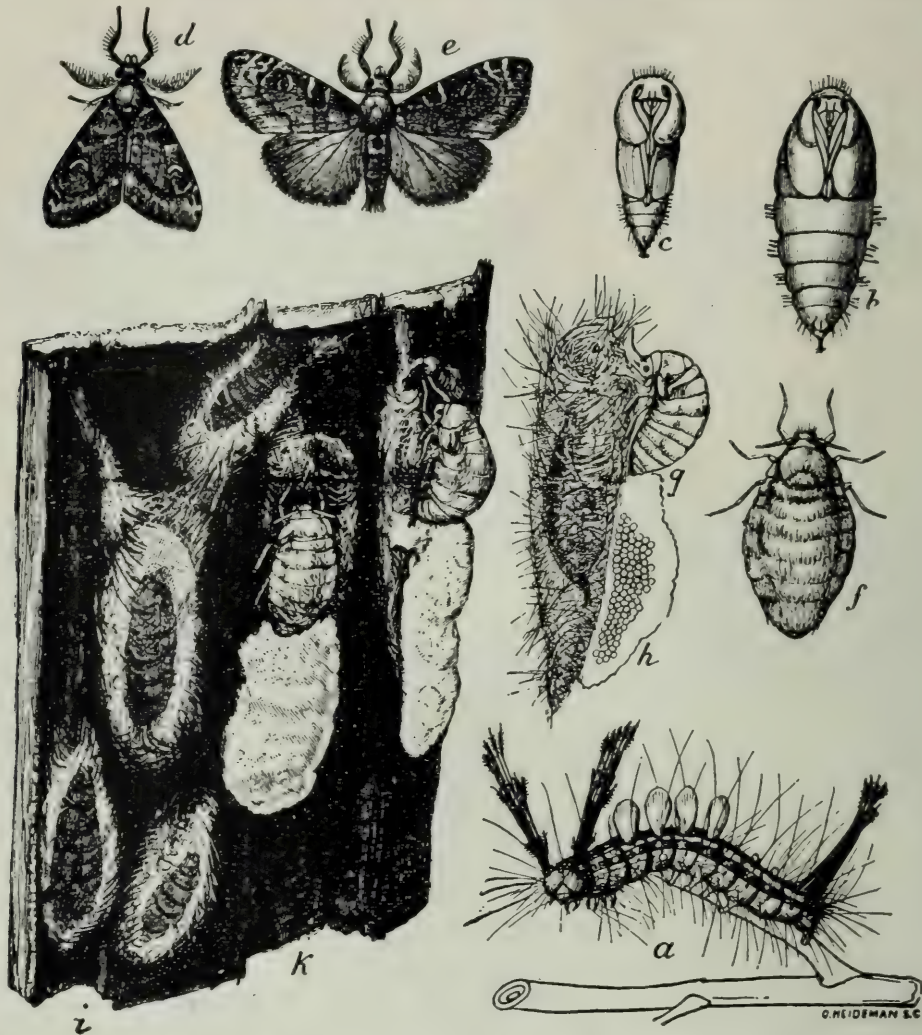


Fig. 9. Tussock Moth in all stages: *a*, caterpillar; *b*, female chrysalis; *c*, male chrysalis; *d* and *e*, male moths; *f*, wingless female moth; *g*, female moth laying her eggs (*h*) on the cocoon from which she has emerged; *k*, female moths, their cocoons and egg masses, on the bark of a tree.

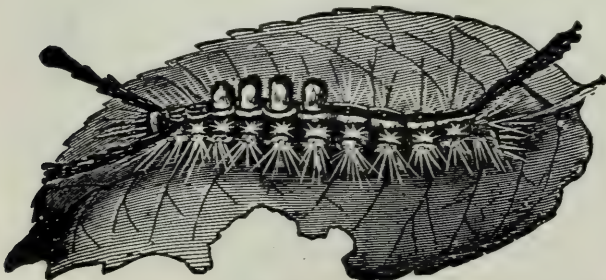


Fig. 10. Tussock Moth; full-grown caterpillar.



Fig. 11. White marked Tussock Moth.

THE WHITE-MARKED TUSSOCK-MOTH (*Hemerocampa leucostigma*), Figs. 9-11. This insect is chiefly known from its attacks upon street shade trees in Toronto and Montreal, and in some other cities and towns, which have caused it to be much discussed in the newspapers and thus made widely known to the public. As it frequently attacks apple and other trees, it may be briefly referred to here. The accompanying figures render description unnecessary. Notwithstanding all the alarm manifested in print, it is really an easy insect to control. The simplest method is to remove and destroy the white egg masses, which are very conspicuous on the trunks and lower limbs of the trees, at any time during the autumn or winter. The wingless female moth on emerging from her cocoon lays her eggs upon it, and covers them with a white frothy substance which soon hardens and protects them from the weather; she then drops to the ground and dies. Numerous other cocoons, without any deposit of eggs upon them, may also be seen; it is unnecessary to remove them, as they contain either the empty shells of the male chrysalids or parasitized larvæ. The young caterpillars are hatched out toward the end of May and may be destroyed, if numerous enough to injure the foliage, by an ordinary spraying with Paris green. In some places there are two broods during the season, the first forming their cocoons about the middle of July and the second in the end of August. Where this is the case spraying should be resorted to, or the egg masses destroyed as soon as possible after they are formed.



Fig. 12. *Datana* Moth.

THE YELLOW-NECKED APPLE-TREE CATERPILLAR (*Datana ministra*), Fig. 12. About the beginning of August the fruit-grower is sometimes surprised at finding a branch on an apple-tree completely stripped of its leaves. On investigation it will probably be found that the culprit is a black and yellow striped caterpillar about two inches long, with a black head and the next segment yellow, from which the name of the insect is derived. These larvæ are gregarious creatures, and are always found clustered thickly together on the limb where they are feeding. When disturbed or alarmed they throw up their front and hind segments with a jerk, and move them from side to side in a curiously threatening manner. They may easily be destroyed by crushing them where they are gathered, or by cutting off and burning the limb. If too high up to reach conveniently, they may be jarred off by rapping the branch with a pole and

then trampled under foot where they fall. The moth is pale brown in color, with darker lines across the wings, and a conspicuous dark velvety patch on the head and thorax.

THE RED-HUMPED APPLE-TREE CATERPILLAR (*Ædemasia concinna*), Figs. 13 and 14. This insect resembles the preceding species very much in habits, stripping completely the foliage of the bough where it is feeding and crowding together when at rest. Similar measures may be adopted for its destruction. The caterpillar has a coral-red head and a hump on the back of the fourth segment of the same color, whence its name. The body is adorned with narrow, black, yellow and white lines and rows of black prickles on the back and sides; the hind segments taper toward the tail and are held up when the insect is not crawling.



Fig. 13. Moth of the Red-humped Caterpillar.

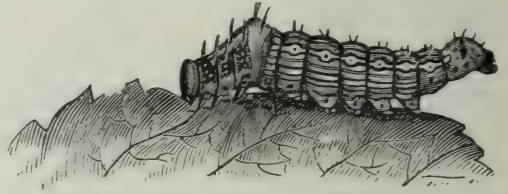


Fig. 14. The Red-humped Caterpillar.

THE SPRING CANKERWORM (*Paleacrita vernata*) and THE FALL CANKERWORM (*Anisopteryx pometaria*), Fig. 15. These two species resemble each other so much that they may be considered together. The moths of the former come out during the first warm days in spring; those of the latter late in the autumn, sometimes after the first snow has fallen. In both the females are wingless, and therefore they do not spread from one orchard to another with much rapidity. Usually their arrival may be traced to some nearby forest tree, as they are very general feeders.

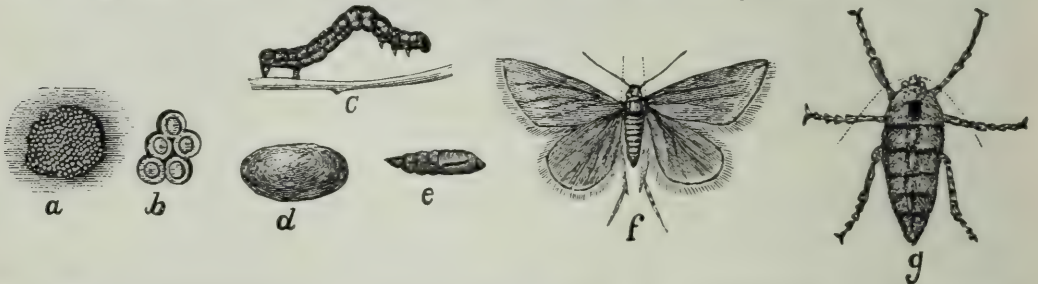


Fig. 15. Canker-worm; *a*, eggs, natural size; *b*, magnified; *c*, caterpillar; *d*, cocoon; *e*, chrysalis; *f*, male moth; *g*, female moth.

The eggs are laid in masses upon the twigs of the trees and the young worms hatch out as soon as the opening buds begin to unfold their leaves. They are slender pale green measuring-worms, so called from their method of crawling by alternately looping up and extending the body; this process is rendered necessary owing to the absence of pro-legs under the middle segments. (Fig. 15, *c*.) Feeding as they do upon the tender young foliage, they are capable of inflicting great damage both to

leaves and blossoms, but they may be destroyed by a spraying early in the season, just as the buds are opening, with Paris green or other poison.

The chrysalids are formed in the ground, and may be destroyed by deep plowing, and the wingless female moths may be prevented from ascending the trees to lay their eggs by bandages of tar or other sticky material, or by projecting flanges of tin or fine wire-netting.

THE EYE-SPOTTED BUD-MOTH (*Tmetocera ocellana*), Fig. 16. Early in the spring the small brown caterpillars of this insect come out of the silken cases in which they have spent the winter and proceed to attack the opening buds, which are speedily ruined. Both leaf and blossom buds are destroyed, the flowers and leaves being tied together to form a shelter and devoured by the hidden inmate; sometimes, especially in young nursery trees, the caterpillar also bores down into the young shoots and causes severe injury. When full grown, about the middle of June, it is half an inch long, dark brown with a black head and collar; it then pupates and the small moth comes out ten days later. The moth is of an ashen-grey color, with a milk-white blotch across the middle of each fore wing and two eye-like spots, one near the tip and the other at the hind angle of the wing; from these spots it derives its name. From the eggs



Fig. 16. Eye-spotted Bud-moth and caterpillar.

now laid the larvæ are hatched in July and feed for a time on the leaves of the tree and then form their silken winter quarters on the twigs. The presence of the insect may be detected by the bunch of blackened and shrivelled leaves tied together at the ends of twigs. In the case of small trees in a nursery these may be cut off and burnt, but it is far better to ward off the attack both in the orchard and elsewhere by spraying the trees with a strong Paris green wash about the first of May and a week later; in any case the spraying should be done before the blossoms are displayed. It is advisable to combine the Paris green with Bordeaux mixture for the destruction of fungus diseases at the same time. If thoroughly done these sprayings will not only kill the larvæ of the Bud-moth, but also a number of other early insects, such as the Case-bearers, Canker-worms, Tent-caterpillars, etc.

THE OBLIQUE-BANDED LEAF-ROLLER (*Cacoecia rosaceana*), Figs. 17 and 18. This is another spring insect which appears soon after the buds open. The little caterpillars roll up and fasten together the young leaves and thus form a shelter in which they feed securely. When numerous they inflict a great deal of damage upon the foliage and sometimes injure the young fruit by gnawing the skin. The moth, which appears about

the end of June, is of a yellowish brown color with oblique darker bands across the fore wings, flat and broad, somewhat bell-shaped when the wings are closed, the hind wings are a paler yellow. The members of the family of moths to which this insect belongs are called Tortrices or Leaf-rollers, and infest a great variety of plants. Several species, besides the one here referred to, may be found on apple-trees. The sprayings recommended for the Codling-moth should prevent any injury from these small caterpillars.



Fig. 17. Leaf-roller Moth, wings open.



Fig. 18. Leaf-roller Moth, wings closed.

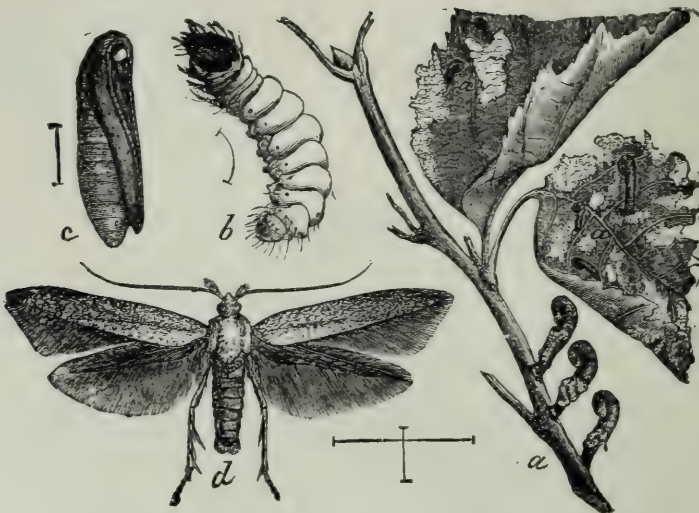


Fig. 19. Apple tree Pistol Case-bearer.

THE CIGAR CASE-BEARER (*Coleophora Fletcherella*) and THE PISTOL CASE-BEARER (*C. malivorella*), Fig. 19. These curious insects are to be found in early spring on the buds of apple and other fruit-trees. They are tiny yellow caterpillars which pass the winter in curved cases formed of pieces of leaves cut out for the purpose; in spring they move to the opening buds and devour the tissue of the leaves. The small shining steel-grey moths of the first species appear about the end of July and lay their eggs, from which the caterpillars are soon hatched, and attain about one-fourth of their growth before winter. At this time they are enclosed in brown leathery cigar-shaped cases and feed upon the soft substance of the leaves; the winter cases are curved and broader. The other species which forms pistol-shaped cases is not so common in Ontario, but may occasionally prove troublesome; its habits are similar to those of the Cigar Case-bearer. Both may be kept in check by the sprayings already referred to.

APPLE PLANT-LICE (*Aphis*), Figs. 20-23. There are at least three species of Plant-lice affecting the Apple in this Province, namely, the Apple Aphis (*A. mali*), the Rosy Apple Aphis (*A. malifoliæ*), and the Woolly Aphis (*Schizoneura lanigera*). The first two infest the tender new growth of the branches and the leaves, which they injure very much by sucking the juices and thus checking the development of the shoots and causing the leaves to shrivel. They are minute pear-shaped creatures, soft-bodied, green, pink or blackish in color, destitute of wings for the most part until the autumn, when the winged forms appear. The third



Fig. 20. Winged and wingless Aphis—greatly enlarged.

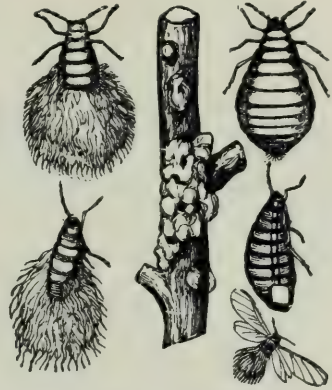


Fig. 21. Woolly Aphis of the apple; much enlarged, except twig.

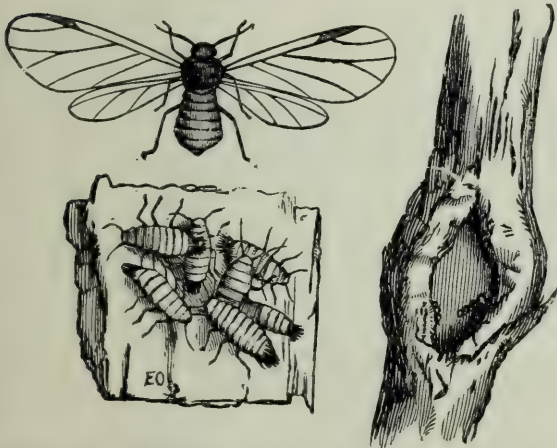


Fig. 22. Woolly Aphis of the apple; winged form, greatly enlarged; a group of young lice magnified; a twig showing injury to bark.

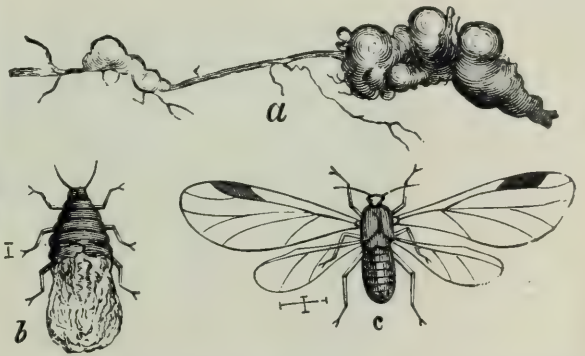


Fig. 23. Apple-root Aphis; a, distortions on a root; b, woolly wingless form; c, winged Aphis—greatly enlarged.

species, the Woolly Aphis, attacks the roots of the Apple, producing knots and swellings and causing much injury, and also is to be found in colonies on limbs and branches, especially where there is any exudation of sap from cuts or wounds in the bark. They are covered with a delicate white material which looks like cotton-wool and gives the special name to the insect. As these minute creatures live entirely by suction, it is impossible to poison their food, but they may be got rid of by substances

which close up their breathing pores and suffocate them. Kerosene emulsion applied as soon as they are observed in the spring, and repeated whenever the colonies reappear, is an effective remedy. Tobacco decoction and whale-oil soap may also be used with good results, and are to be preferred where only a few trees require to be treated. The underground form is very difficult to get at, but may be destroyed with bisulphide of carbon poured into holes made in the ground above the infested roots and then covered up.

SCALE INSECTS.

The most dangerous enemies of fruit-trees are undoubtedly the Scale Insects, of which we have several destructive species in Canada. The worst of these is certainly the notorious SAN JOSE SCALE (*Aspidiotus perniciosus*), Fig. 24, which is now firmly established in the Niagara fruit district and in the Counties of Essex and Kent; it will probably also be found in some other localities. So much has been published respecting this insect in the Reports of the Entomological Society of Ontario and in the agricultural and horticultural periodicals, and the pest has become so widely known, that it is unnecessary to enter into any details here. While its extermination is hardly to be expected, it can be kept under control and even got rid of in an orchard by persistent and careful spraying with the lime-sulphur wash, provided that it is properly made and

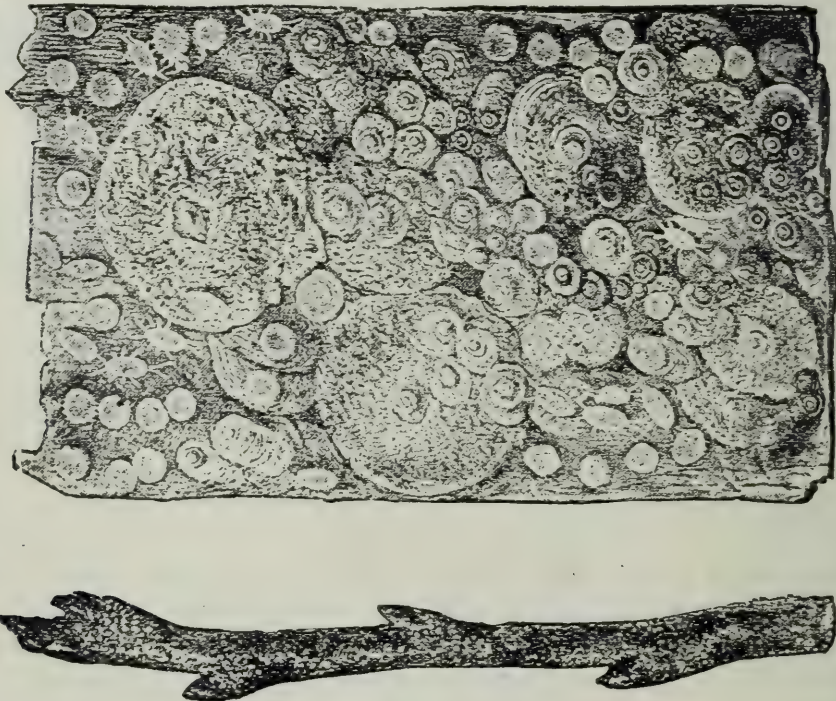


Fig. 24. San José Scale.

thoroughly applied. Recent Bulletins (Nos. 154 and 157) give full particulars as to the ingredients and method of manufacture of this wash; it should be applied toward the end of April or beginning of May before the buds on the trees show signs of opening. One thorough application will destroy almost all the scales, but a very few survivors will soon restock a tree, as they are so extraordinarily prolific. It is necessary, therefore, to repeat the spraying year after year until none whatever are left. The task is a disagreeable one, and the labor involved is expensive, but it will pay in a single season through the improved quality and yield of the fruit; while its neglect simply means the speedy death and loss of the entire tree.

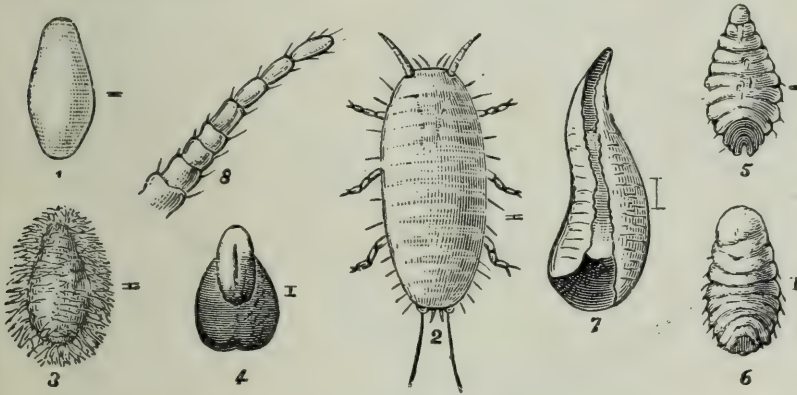


Fig. 25. Oyster-shell Bark-louse.



Fig. 26. A Scale greatly enlarged.

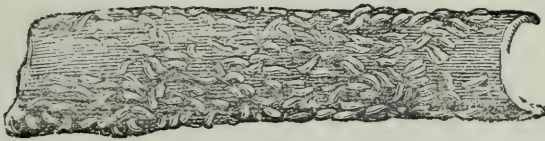


Fig. 27. Scales on a twig.

THE OYSTER-SHELL BARK-LOUSE (*Mytilaspis ulmi*), Figs. 25-27, ranks next to the preceding as a destructive scale insect. It is to be found everywhere throughout the Province, and inflicts an immense amount of damage on Apple and other fruit-trees; it is especially abundant in old and neglected orchards. Fortunately it is single-brooded, and therefore does not increase very rapidly; if it were continuously brooded, like the San José Scale, it would long ago have completely wiped out the Apple and many other fruit-trees of Ontario. It may be readily identified by its peculiar shape, which resembles that of an oyster-shell, and may usually be found in large numbers, sometimes completely encrusting the bark of twigs and branches; occasionally individuals even make their abode on the fruit. During the winter the insect is in the egg stage and protected by the old scales; about the end of May and beginning of June, the yellow lice are hatched out and wander about for a short time, looking for a suitable place where they may attach themselves to the bark. This is done by inserting the beak into the tissue, and there the creature soon becomes covered with a scale and remains for the rest of its life sucking

the sap of the tree. Twice in the season the insect sheds its skin and assumes a larger one, leaving the cast-off portion still attached to the new. In the autumn the adult female lays her eggs and dies. The lime-sulphur wash recommended for the San José Scale is a complete remedy for this one also. When inconvenient to make it, good results may be obtained by a thorough wash with lime alone (one pound and a half quickly slaked to a gallon of water), applied after the leaves fall in the autumn and again before the buds open in the spring. When the lice are first hatched out and are running on the limbs they may be destroyed with kerosene emulsion or a whale-oil soap solution.

THE SCURFY BARK-LOUSE (*Chionaspis furfurus*), Fig. 28, also attacks the Apple and some other fruit-trees, but is not so widely distributed as the preceding species, which it somewhat resembles in shape. The eggs are of a purplish color, and the adult scale is white and conspicuous. The figures will enable anyone to distinguish the two species. Their life-histories and habits are the same, and consequently the same treatment may be adopted for both.



Fig. 28. The Scurfy Bark-louse.

Other Scales, such as the Forbes and Putnam's, may be found on Apple-trees, but thus far have not been abundant, and therefore have attracted little attention. Should they occur in injurious numbers at any time, they may be got rid of with the lime-sulphur wash.

APPLE-TREE BORERS.

THE ROUND-HEADED APPLE-TREE BORER (*Saperda candida*), Fig. 29, is a very serious enemy to young trees. The parent beetle is a handsome insect of a chocolate brown color with two bands of chalky-white extending from one extremity to the other on the upper surface and with long jointed antennæ. The female lays her eggs in an incision which she makes in the bark during the month of June; the young larvæ tunnel under the bark and feed upon the sap-wood, living for three years in that condition, and making larger and deeper burrows as they increase in size. Their presence may generally be ascertained by the little heap of sawdust-like castings at the base of the affected tree. Working under cover as they do, they cannot be reached by ordinary poisons, and can only be destroyed by the insertion of a wire into their boring, or by cutting out with a knife. The former operation is somewhat uncertain, and the latter may injure the tree to a serious extent. The only safe remedy, then, is to prevent the adult from laying its eggs upon the tree.

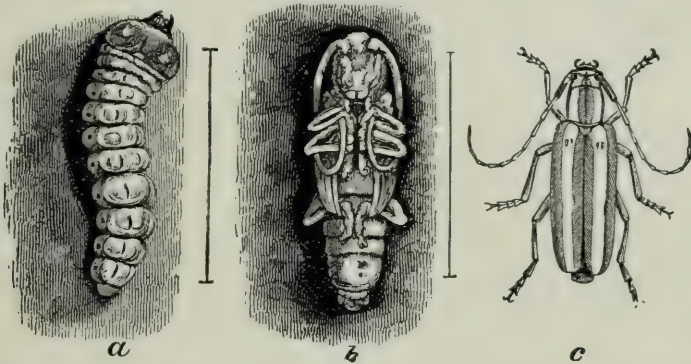


Fig. 29. Round-headed Apple-tree Borer: *a*, grub; *b*, pupa; *c*, beetle.

When the borers are known to be in a nursery or young orchard, the trees may be protected by wrapping a few sheets of paper around the trunk extending from the surface of the ground to two feet in height. At the bottom the paper should be hilled up with earth, and at the top made tight with a cord of bast or other material that will readily break with the growth of the tree. Above the paper the trunk should be washed from the limbs downward with soft-soap reduced to the consistency of paint by adding a solution of washing soda. Whale-oil or common soft-soap may be used. The object of this is to prevent the beetles from laying their eggs on the base of the tree and hindering those that have completed their transformations from getting out, by means of the paper protection. The wash higher up will deter the insect from laying eggs anywhere else.

THE FLAT-HEADED APPLE-TREE BORER (*Chrysobothris femorata*), Fig. 30, is much more common than the preceding species and differs in many respects in its habits and life-history. The adult beetle is about half an inch in length, somewhat flattened above and with short antennæ. The upper surface is dark metallic brown, while beneath it is bright copper color; the thighs of the fore legs are armed with a stout tooth, from which the insect's specific name (*femorata*) is derived. It delights in the hot sunshine and may be found on logs and the trunks of trees. Like most wood-borers, it chiefly attacks trees that are dying or weakened by disease, and will bore into the limbs and branches as well as the trunk; its chief injuries, however, are done to young and newly transplanted trees. The eggs are laid late in May and in June in crevices of the bark, through which the newly hatched grub bores, and forms its broad burrow immediately under the bark. The channels thus made sometimes extend completely round, so as to girdle and cause the death of the tree or limb.

This larva differs very much from the preceding in having the segment next the head broad and flat and much larger than those following, and is usually to be found with the posterior half of the body very much curved; it takes but a single year to complete its life period. Attacking, as it does, all parts of the tree, the preventive measures suggested for the Round-headed Borer are of no avail unless the wash is applied to limbs and branches as well as trunk. When discovered the grubs may be killed with a knife; but their presence is not readily seen. Wood-peckers, however, have no difficulty in finding out the burrows and devour large numbers, and the presence of these birds in the orchard should by all means be encouraged.

As this beetle attacks a number of forest trees, such as oak, beech, birch, elm, etc., as well as mountain ash and many other cultivated trees, it is necessary to see that no dead or dying trees are left near the orchard to serve as breeding places. They might, however, serve as traps, if care was taken to burn them up before the month of May.

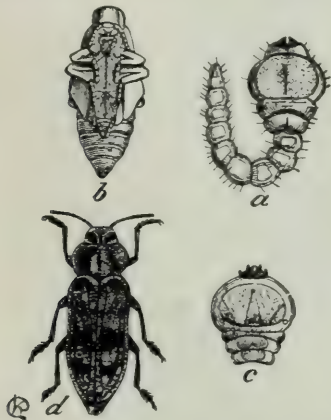


Fig. 30. Flat-headed Apple Tree Borer: a, grub; b, pupa; c, enlarged head and following segments; d, beetle.

2a Bull. 158.

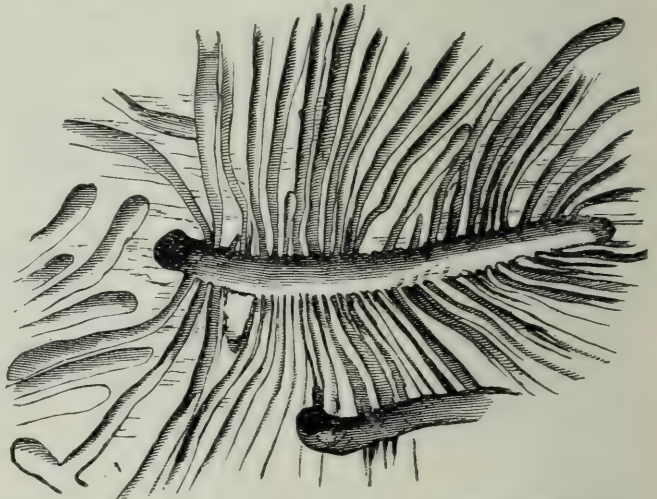


Fig. 31. Tunnels under the bark made by a *Scolytus* beetle.

THE SHOT-HOLE BORER, or FRUIT-TREE BARK BEETLE (*Scolytus rugulosus*), Fig. 31, is another enemy of Apple and other fruit-trees. The former name is given to the insect from its presence being made known by a large number of small round holes, looking as if they had been made with fine shot from a gun. These are the openings which the beetle has made in penetrating the bark and also in coming out. The mature insect is cylindrical in form and black in color and about one-tenth of an inch in length. Though so small, it does a great deal of damage by making a great number of galleries in the surface of the wood just beneath the bark, which cause it to dry up, and by boring vertical tunnels deep into the wood. Being so minute its presence is not known until it has produced the "shot-holes" (which are often indicated by exudations of gum in the case of Cherry-trees), and inflicted much damage. The only remedy seems to be to cut off and burn all affected limbs, and to leave no dead wood lying about to serve as breeding places.

As a general rule this insect attacks only dying trees or diseased limbs; those that have been seriously injured by the Oyster-shell Barklouse or other scale insects are especially liable to be affected by this borer. In some few instances the branches of apparently healthy trees have been attacked; this may have been occasioned by a superfluity of the beetles and the absence of more suitable breeding places.

FUNGUS DISEASES AFFECTING THE APPLE.

APPLE SCAB (*Venturia inequalis*), Fig. 32. The scab of the apple and pear is a very familiar disease in Ontario. It attacks leaves, shoots and fruit, and causes the small apples to fall and the older ones to become irregular and scabby. Dirty olive patches appear first, then enlarging they run together, and become darker in color. These patches are masses of spores which are blown by the wind to other leaves and young fruit. Many generations occur in a season. The fungus hibernates among the leaves on the ground and in the crevices of the tree. Spraying with lime-sulphur wash in the winter will doubtless kill many of the hibernating spores. Spraying with Bordeaux mixture before the opening of the buds and once or twice after the "setting" of the fruit is recommended. Removing the fallen leaves will also tend to lessen the disease.

SOOTY BLOTCH (*Leptothyrium pomi*). This disease has been reported from many parts of Ontario as doing injury to Greening and Baldwin Apples. The injury to the fruit at first is chiefly to its appearance, but this is sufficient to greatly lessen its market value. The skin of the apple is ruptured by the fungus, causing the fruit to wilt easily, and thus injuring its keeping qualities. The mycelium or body of the fungus is black and forms a prostrate growth of matted threads which nearly covers the surface of the fruit. The spraying with Bordeaux mixture, as for Apple Scab, will keep this fungus in check. To be most effective the trees should be sprayed when the fruit has attained considerable size.

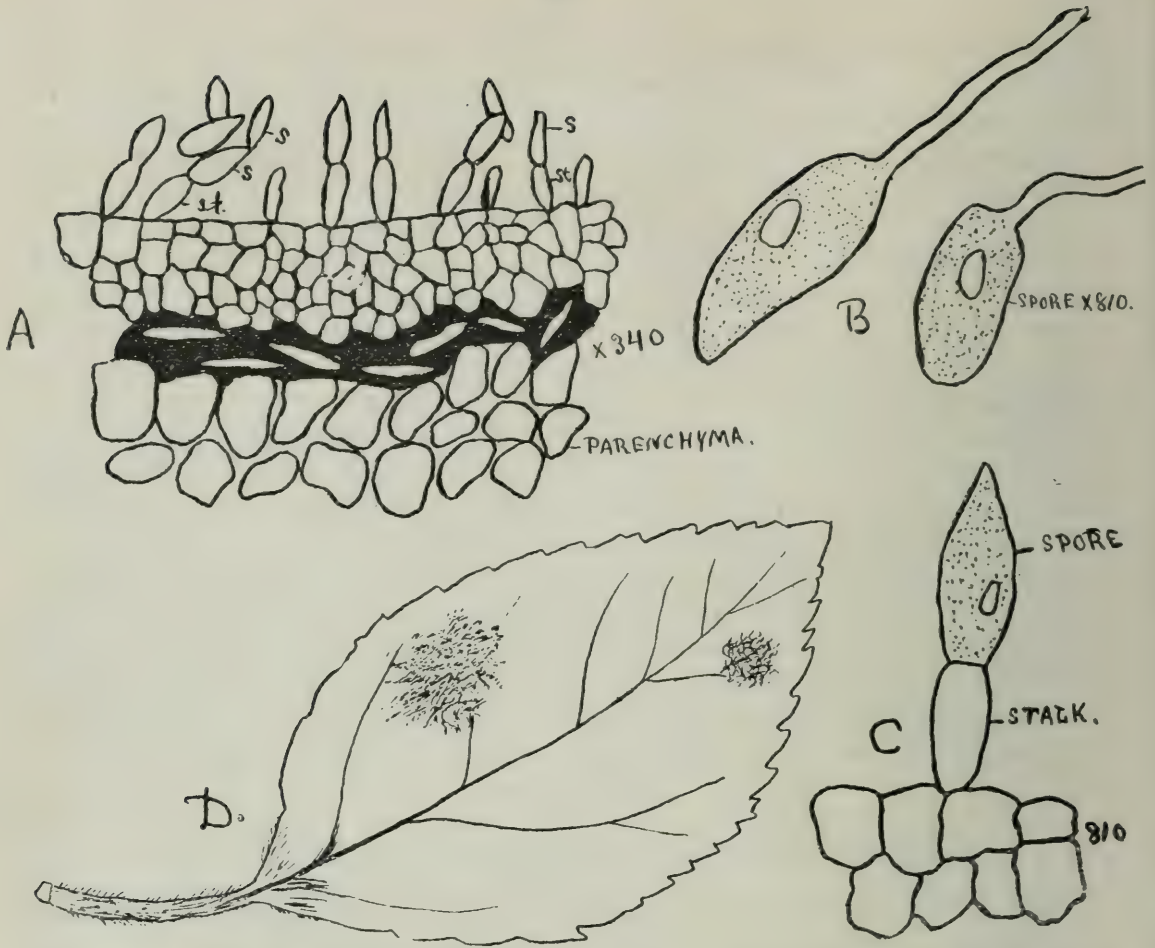


Fig. 32. A, section of an apple showing spores, *s*, and stalks, *st*, on the surface; B, germinating spores; C, part of A on a larger scale; D, leaf affected with apple scab.

APPLE LEAF-SPOT (*Phyllosticta*, sps.); Fig. 33. This is a very common disease of the leaves of the Apple. Light colored spots are found scattered over the surface of the leaves; the spots are somewhat circular or irregular in outline, the lighter portion being surrounded by a reddish ring. In the centre of the light area are usually found darker colored spots, which are the spores. The spots are 2-20 to 3-20 inch in diameter. This is not a very serious disease, and the treatment for Apple Scab will be found quite effective for these leaf spots.

BITTER ROT (*Glomerella rufomaculans*), Fig. 34. Usually appears as small rotten sunken spots when the apple is about half grown. These spots rapidly increase in size, several of them frequently running together and forming a large area. This increase in size is very noticeable in warm weather. Numerous, small dark fruiting pustules arise which are arranged more or less in concentric rings. The whole apple rapidly becomes rotten, the rotten part possessing a very bitter taste. The fungus passes the winter as cankered areas on the branches, frequently at the base of old fruiting spurs. Cutting out these diseased areas, and the treatment for Apple Scab, together with the gathering of rotting fruit, is recommended.



Fig. 33. Apple leaves affected with Leaf Spot (*Phyllosticta pirina*).

BLACK ROT (*Sphaeropsis malorum*), Fig. 35. This is a serious pest of ripe apples. It attacks the leaves, twigs, stems and fruit. On the leaves it appears as little brown spots much like the Apple Leaf-Spot disease. On the twigs or stems it appears as blackish spots and the fruit when attacked turns at first reddish brown and later black. The spores consist of minute black bodies just under the skin. It differs from Bitter Rot in not having the spores arranged in concentric rings. Bitter Rot attacks the green fruit, while the Black Rot only attacks the ripe fruit, and has no bitter taste. Diseased fruits should be destroyed wherever they may be found. The treatment which is used for Apple Scab is also recommended for Black Rot.

POWDERY MILDEW (*Podosphaera leucotricha*). This species of Powdery Mildew often does much injury to young seedling Apple-trees. It appears as a powdery-like covering over the surface of the leaves. In late summer small black bodies appear on the leaf; these contain the winter spores of the fungus. Spray the seedlings shortly after buds open and at intervals of three or four weeks with Bordeaux mixture.

LEAF-RUSTS (*Gymonosporangium*, sp.). Wherever Red Cedar is found in Ontario, leaf-rusts on Apples and Pears are fairly plentiful. This is due to the fungus spending a part of its life on the Cedar. Large yellow spots are to be found on the under surface of the leaves of the Apple and Pear, and sometimes the spots are so numerous as to cover the whole of the under surface of the leaf. Since we know that Cedars harbor these rusts, they should be carefully watched and destroyed if necessary.



Fig. 34. Bitter Rot Canker (after Burrill).



Fig. 35. Two young trees showing cankers due to the Black Rot Fungus, and produced by artificial inoculation by Paddock; a, pear; b, apple.

EUROPEAN CANKER (*Nectria ditissima*), Fig. 36. This disease is usually found on the branches of old and neglected trees, obtaining an entrance into the tissues through wounds. The fungus spreads outwards from its original centre, forming a series of concentric cracks, some of which attain considerable size, thus giving them a very characteristic appearance. The diseased portion is slightly sunken and somewhat darker in color than the normal branch; and has a very rough and scaly appearance due to the bark peeling off. Small red roundish fruiting bodies may be seen along the edge of the cracks. All cankered limbs should be cut out and any large cut surfaces be given a coat of paint to prevent the entrance of the spores.



Fig. 36. Nectria Canker.

INSECTS AFFECTING THE PEAR.

Most, if not all, of the insects that attack the Apple are equally injurious to the Pear, but there are a few additional kinds to which attention must be drawn.

THE PEAR-TREE PSYLLA (*Psylla pyricola*), Figs. 37, 38. Many complaints have been made of late years respecting injuries to Pear-trees by this minute insect. It belongs to the same order as the plant-lice and scale insects which are so prolific and destructive. The winter is passed in crevices of the bark, or in rubbish or other shelter, by the mature winged fly, which is brick-red in color and about an eighth of an inch in length. About the middle of April the fly comes out of its hiding place and lays its yellow eggs on buds and twigs wherever there is a crease or scar to afford protection. In three weeks' time the eggs hatch and the nymphs attach themselves to the leaves or opening buds. Like the aphids, they secrete large quantities of "honey dew" which drips upon the foliage and branches below, and becomes covered with a black fungus growth. As there are several broods, probably four, in the year, the colonies increase and multiply enormously, and are a heavy drain upon the vitality of the tree. Fortunately they are kept somewhat in check by their natural ene-

mies the Aphis-lions (*Chrysopa*) and the Lady-bird beetles, which in both larval and adult stages devour immense numbers of them.

The best remedy for the insect is a thorough application of the lime-sulphur wash in early spring, as recommended for several other insects. Lime alone would be effective, but the addition of sulphur helps to clean off the black fungus, and the complete mixture serves at the same time for the eradication of scale and other pests. If it should be found necessary to treat the trees in summer kerosene emulsion will kill the nymphs, but it is likely at the same time to kill our friends the Aphis-lions and Lady-bird beetles, and may also injure the foliage.



Fig. 37. Pear-tree Psylla, greatly enlarged (after Marlatt).



Fig. 39. Pear and cherry-tree Slug.

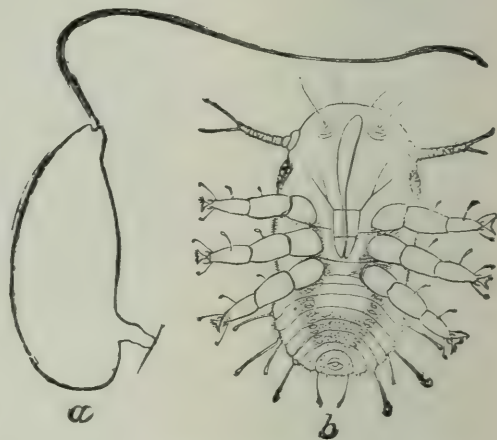


Fig. 38. Pear-tree Psylla; a, egg; b, nymph; greatly enlarged (after Marlatt).

The PEAR-TREE SLUG (*Selandria cerasi*), Fig. 39. Leaves of Pear-trees may sometimes be noticed hanging withered and brown on the twigs, and others with transparent patches where all ought to be green. A close inspection of the latter will usually reveal a small slimy blackish or deep greenish slug, shaped somewhat like a tadpole and having an odor resembling that of red ink. This is the larva of a saw-fly, a glossy black four-winged creature about one-fifth of an inch in length. The fly lays her eggs early in June in slits which she makes in the leaves by means of her saw-like ovipositor; these hatch out about a fortnight later, and the slugs begin to devour the leaves, eating out irregular patches and leaving only the skin of the under surface. A second brood is to be found in August. Spraying with powdered white hellebore in water or with Paris green will speedily destroy the slugs. Dusting with lime is also recommended on account of its burning properties. Dust of other kinds, such as ashes, road-dust, etc., have been tried, but they merely stick to the slimy surface, and when the insect moults, which it does four times, it leaves its old skin and the dust behind. This insect is equally common on Cherry-trees and sometimes on Plum.

FUNGUS DISEASES AFFECTING THE PEAR.

PEAR SCAB (*Venturia pirina*). This fungus is very closely related to the Apple Scab. It is one of the two common diseases in Ontario that cause cracking of the fruit. It may be distinguished from Pear-leaf Scald by the absence of the reddish brown coloration which is conspicuous in spots of the Pear-leaf Scald. The habits of this fungus are much the same as Apple Scab and the same treatment is recommended.

PEAR BLIGHT (*Bacillus amylovorus*). This fungus attacks Pears, Apples, and allied fruit-trees. It attacks and rapidly destroys blossoms, young fruit, young twigs, and the disease often runs down the living bark, killing some of the larger branches. The disease, however, varies greatly in severity. The blossoms are first attacked just when the flower-clusters are about to open; they turn black and dry up as if they had been killed by frost. The disease frequently spreads from tree to tree with great rapidity, the spores being carried from flower to flower by insects. The black appearance of the attacked parts is very characteristic. The remedy is to cut out and burn immediately the affected branches as soon as possible after the disease appears, removing the branch some inches below where the disease can be seen.

PEAR-LEAF SCAID (*Entomosporium maculatum*). This very destructive fungus attacks both leaves and fruit of the Pear; sometimes entirely destroying the foliage. Small pustules appear whose average size is a little less than 1-10 of an inch; these consist of circular spots projecting slightly from the surface of the fruit and leaf and are dark reddish-brown in color. Upon the surface of these may be seen small whitish colored spots which are dotted with black spots irregularly over the surface. Like the Scab, it causes cracking of the fruit. The fungus hibernates on the bark of the host. Spraying with Bordeaux mixture holds the disease in check; the first spraying should be applied, using a very dilute solution, as the leaves are expanding. Clean culture is also recommended.

PEAR-LEAF SPOT (*Septoria piricola*). This is a very common disease of Pear leaves. It appears as distinct circular, oval or subangular greyish spots surrounded by a purplish or reddish border, giving the spots a characteristic appearance. The size varies somewhat, but as a rule they are rather less than 1-10 of an inch in diameter. The spots on the under side of the leaves are brown surrounded by a darker ring. The treatment of Pear-leaf Scald is recommended for Pear-leaf Spot.

The Leaf Rust (*Gymnosporangium*) of the Apple sometimes attacks the Pear and injures it to some extent. The Brown Rot (*Sclerotinia fructigena*) of the Plum is occasionally found on the fruit of the Pear.

INSECTS AFFECTING THE PLUM.

The caterpillars of a number of moths and a few butterflies feed upon the leaves of Plum-trees, such as the large and handsome Plum-tree Sphinx (*Sphinx drupiferarum*), several Dagger-moths (*Acronycta*), and

others. None of them, however, come in sufficient numbers to cause any appreciable injury to the trees and may therefore be disregarded by the fruit-grower. The most formidable enemy is the notorious

PLUM CURCULIO (*Conotrachelus nenuphar*), Figs. 40, 41. The work of this insect is so well known that it hardly needs description. The adult is a very small beetle belonging to the family of Snout-beetles, otherwise known as Curculios or Weevils. It is about one-fifth of an inch in length, dark in color, with a pair of shining black humps on the middle of the back, followed by a pale yellowish band; the snout is short and thick. It looks very much like a rough bit of bark and would therefore escape notice by those unfamiliar with it. The winter is spent in some hiding place by the adult beetle, which comes out when spring days are warm and flies to the trees in readiness for destructive work. I have often found it in the blossoms of plum-trees, probably feeding on the pollen, and waiting till the fruit becomes large enough for its attack.

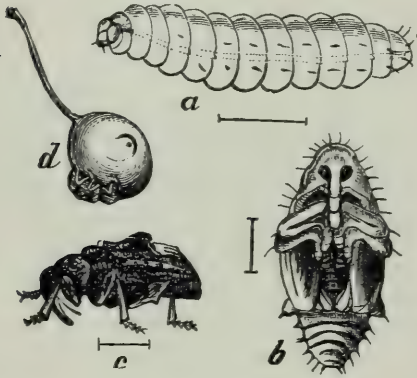


Fig. 40. Plum Curculio; a, larva; b, pupa; c, beetle; d, young fruit attacked.



Fig. 41. Plum Curculio attacking young fruit.

When the plum is as large as a good-sized pea, the female beetle bores a hole in the side, deposits an egg in it, and then cuts a crescent-shaped slit beside it so as to undermine the egg and prevent its being crushed by the growth of the fruit. The tiny grub that hatches from it buries itself in the green flesh and devours the greater part of it, especially around the stone. The injury causes the plum to fall prematurely to the ground; the grub then completes its growth, buries itself in the earth, transforms into the chrysalis state and finally develops into a beetle. Spraying with Paris green immediately after the blossoms have fallen will kill a large number of the beetles before the egg-laying is completed. Another method, which many fruit-growers consider more effective, is to jar the trees by sudden blows upon the limbs and catch the beetles which fall on a sheet below; all that are captured in this way should be destroyed at once before they have time to fly away. This should be done

before and while the trees are in bloom, and be performed morning and evening, when the beetles are more sluggish than in the heat of the day. A further method is to lay pieces of board about the base of the trees and each morning go around and collect the beetles which have found them a convenient shelter during the chill hours of the night. Whatever plan is adopted, it is all important that all fallen fruit should be daily gathered up and destroyed before the grubs have left them to enter the earth.

This insect attacks apples, pears, and cherries also, but is most abundant on plums.

FUNGUS DISEASES AFFECTING THE PLUM.

PLUM LEAF-RUST (*Puccinia pruni*). Some years this disease is very common in many parts of Ontario. It appears as small reddish or brown spots dotted all over the under surface of the leaves and so abundant in some cases as to almost cover the entire surface. On examination these spots are found to consist of a fine reddish brown powder, the spores of the fungus. Clean culture is recommended.

PLUM SCAB (*Cladosporium carpophilum*). This disease is very common on Plum-trees. It is more common on the Wild Plum than on the cultivated species, and hence the danger of having Wild Plums near the orchard. The brownish or olive colored spots appear on the fruit a short time before ripening; these spots run together and sometimes cover the surface of the fruit. Spraying with Bordeaux mixture, the same as for Apple Scab, is recommended.

PLUM POCKETS (*Exoascus pruni*). A fairly common disease of the Plum in Ontario. The "pockets" are quite different in shape from the normal plums, being somewhat roughly oblong bodies of about an inch in length. The fungus attacks the ovaries of the plum; these swell rapidly, the soft tissue of the fruit becoming very spongy, and there is no development of stone. When mature the outside is covered with a whitish bloom. It is a perennial, living from year to year in the young growth of the tree and proceeding thence in spring into young shoots and ovaries. Cutting and burning the affected branches and trees is the only sure way of exterminating the disease.

BROWN ROT (*Sclerotinia fructigena*), Figs. 42 and 43. This is the most injurious disease of the Plum. The infested fruit becomes rotten, then gradually dries up, forming a shrivelled mass which usually hangs on the tree all winter. The surface of diseased fruits is covered with small brownish tufts which contain the spores. These spores, whether on the ground or on the tree, are blown by the wind to the young fruit, where the spores germinate and start fresh rot. By removing the diseased fruits from the tree and ploughing under those that fall to the ground the disease will be greatly lessened. Spraying with Bordeaux mixture after the young fruit has set will also keep the fungus in check.

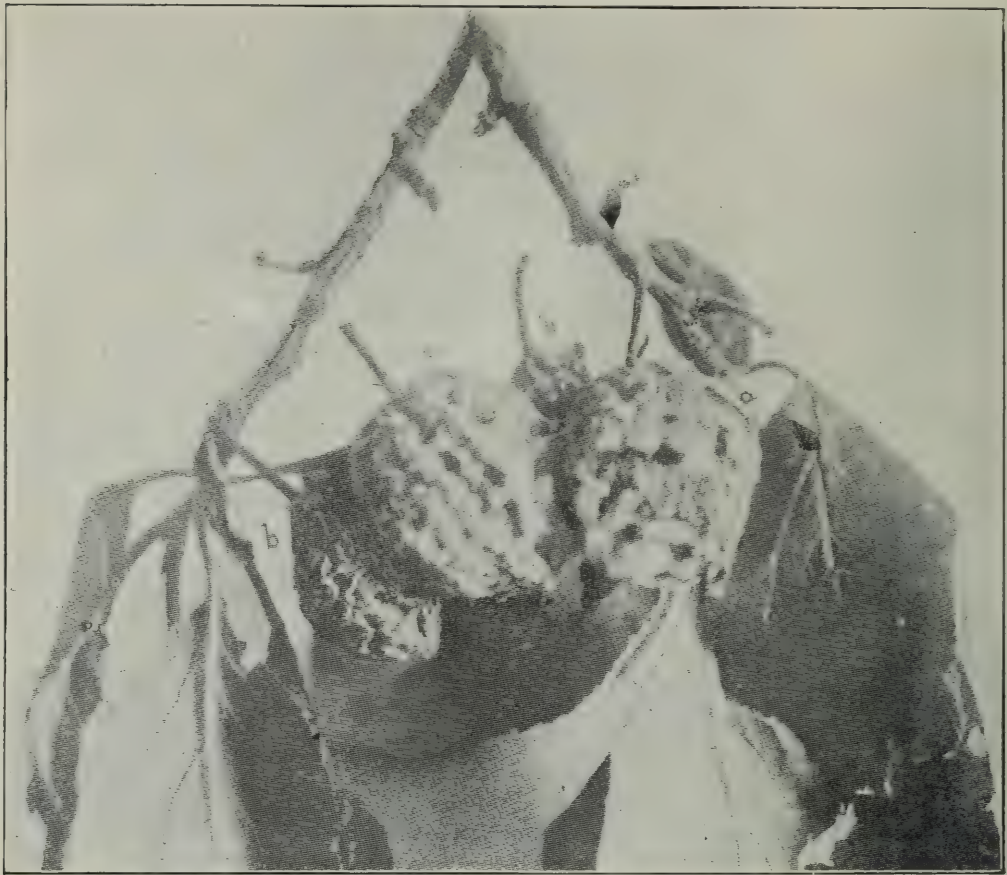


Fig. 42. Brown Rot of Plum (*Monilia fructigena*); a, plum in the soft stage with abundant production of spores; b, plums in the dry, "mummy" stage (after N. Y. Ag. Exp. St. Bulletin).

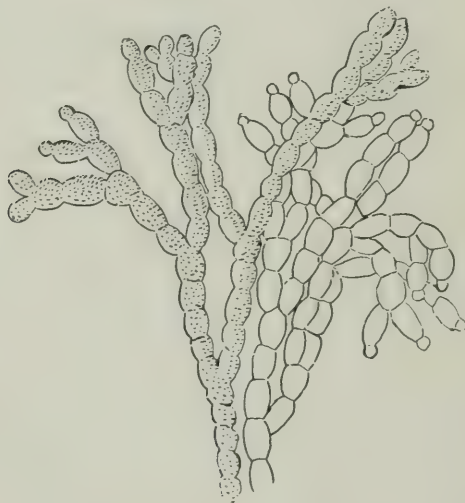


Fig. 43. Spores of Brown Rot of Plum (*Monilia fructigena*).

INSECTS AFFECTING THE CHERRY.

The Cherry is affected by a number of the insects already considered in connection with other fruit-trees. The Pear-tree Slug is quite as abundant on the leaves of the Cherry-trees as on Pear-trees; the Plum Curculio attacks the fruit, often very severely; the Tent-caterpillars, Fall Web-worm, Tussock-moth, Canker-worms, Eye-spotted Bud-moth, Leaf-rollers and Case-bearers all devour the foliage; and the scale insects suck the sap and lower the vitality of the trees. In addition to these formidable enemies attention may be drawn to

THE CHERRY APHIS (*Myzus cerasi*). This insect differs from most of the plant-lice in being black instead of the usual green color. It often appears on the leaves at the ends of the boughs in enormous numbers, causing the leaves to curl up and arresting further growth. The structure and habits of this species are similar to those of the Apple Aphis; it passes the winter in the egg state on the twigs of the tree. The remedies already mentioned are effective in this case also, and should be applied as soon as the first colonies are noticed. Usually the presence of the insect is not observed until it has become very numerous and the terminal leaves all over the trees are affected. Lady-bird beetles (Fig. 44) and Aphis-lions (Figs. 45, 46) are usually to be seen feeding voraciously on the plant-lice and assisting very materially in the reduction of their numbers.



Fig. 44. Lady-bird Beetles.

Fig. 45. Aphis-lion and its eggs.

Fig. 46. Eggs and larva of Aphis-lion.

FUNGUS DISEASES AFFECTING THE CHERRY.

POWDERY MILDEW (*Podosphaera oxyacanthæ*). This fungus attacks the leaves of the Cherry, particularly the young ones; also the tender shoots. It appears on the leaves in small white patches, which soon spread and run into each other, forming a thin white felt, which in some cases may cover the entire surface of the leaf. Later on the white felt becomes thickly studded with innumerable minute black spots, which are the "fruit" of the fungus. In later stages leaves become yellowish and spotted and useless to the plant. Spray with Bordeaux mixture after the leaves have fully expanded and at intervals of three or four weeks. Three sprayings should be sufficient.

BLACK KNOT (*Plowrightia morbosa*). This Cherry and Plum fungus causes large and more or less irregular swellings on the branches which are more usually present upon the younger branches and the fruiting twigs. They generally appear on one side of the branch only, thus leav-

ing the other side perfectly healthy. At first the swellings are lightish brown in color, but the color deepens as the season advances until in the fall they vary from dark brown to black. The surface of the swellings is covered with small warty excrescences, which give to them a very typical appearance. The remedy is simple—removing with a knife and burning the knots. Where a tree is badly infested it is advisable to cut it down and burn it and thus prevent the disease spreading to others.

SHOT-HOLE FUNGUS (*Cylindrosporium padi*), Fig. 47. This fungus attacks the leaves of the Peach, Plum, Cherry, Apricot and many wild species of allied plants. It appears as brownish or reddish, circular, oval or somewhat irregular spots on the leaves. The spots vary from 1-20 to 3-20 of an inch in diameter, 1-10 being about the average size. Later on the leaves become perforated by holes caused by the dropping out of the withered spots. In some cases large irregular holes may occur, due to the running together of a number of spots. Many of the spots show concentric rings of different shades of brown. Clean culture and spraying with Bordeaux mixture when the leaves are fully expanded will keep this fungus in check.



Fig. 47. Shothole Fungus of plum and cherry (*Cylindrosporium padi*); a, b, c, leaves in various stages of attack; d, the spores of the fungus (much magnified).

INSECTS AFFECTING THE PEACH.

The war against injurious insects is almost heart-breaking to the peach-grower, as the special enemies of this tree make such serious attacks upon it and its less robust constitution causes it to succumb much more readily than the sturdy Apple and other fruit-trees. It is particularly unfortunate, therefore, that the *San José Scale* should have become established in those southern counties of Ontario where alone the peach will thrive. This deadly insect should be constantly watched for and the prescribed treatment applied as soon as the proper time has arrived. If neglected, the tree is doomed to an early death and might as well be cut down and burnt at once. Where peaches are grown on a large scale, it will pay to fumigate with hydrocyanic acid gas, for which it is necessary to have tents large enough to cover an entire tree. As this is a very dangerous poison, the fumes being destructive of all animal life, it should not be employed by unskilled persons. With proper care and the requisite knowledge, it may be used to great advantage and will be found to clear the trees of injurious insects of every kind that may be upon them.

THE PEACH LECANIUM SCALE (*Lecanium persicæ*). On the twigs and branches may sometimes be found large, soft-shelled, brown scales, very convex and resembling in size and shape the half of a split pea. Like all other scale insects, these live by sucking the sap of the tree and when numbers are present impair its vitality very much. The remedies prescribed for the other scales are equally effective for this. Lecanium scales of many kinds may be found on most fruit and forest trees and upon a great variety of shrubs and plants; usually they are not very numerous or injurious, but occasionally they occur in immense numbers, crowded thickly together, and inflicting much damage. If the affected tree cannot be treated in the prescribed manner, it had better be cut down and burnt in order that it may not become a centre of danger to others. Several of the species do not confine themselves to any one kind of tree, but will spread to all that may be within reach.

THE TERRAPIN SCALE (*Eulecanium nigrofasciatum*), Fig. 48, to which public attention has recently been drawn in the daily press, is a hard hemispherical scale, red in the middle, with black streaks, proceeding to the sides and a black margin; the colors and markings vary to some extent, and individuals may be found with very little red and others with little or no black. When observed on a tree they are usually in immense numbers, thickly clustered together and often overlapping each other. In shape and markings they bear some resemblance to a turtle and have therefore received the name of "the Terrapin Scale." The specimens that we have seen were sent in from St. Catharines, Windsor and Walkerville, and in each case were found on Maple-trees. Many of them were perforated, showing that they had been destroyed by a minute parasitic insect. This scale is widely prevalent in the Northern and Eastern States, but is not common yet in Ontario.

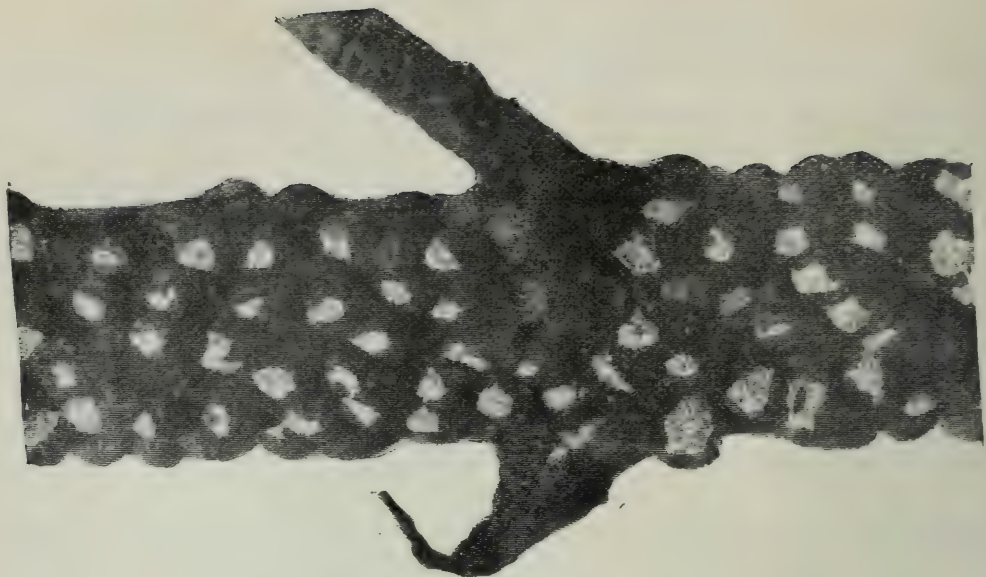


Fig. 48. Terrapin Scale (*Eulecanium nigrofasciatum*). Adult females on twig of peach; enlarged about three times (after Sanders, U. S. Dept. Agr.).

It attacks a large number of wild and cultivated trees and shrubs, and is especially injurious to peach trees. As it will readily spread from one tree to another, it is important that any wild trees found to be infested should be cut down and burnt at once. The only remedy for the insect when it attacks fruit-trees is to spray with kerosene emulsion in the fall and winter or in early spring before the leaves come out.

THE PEACH-TREE BORER (*Sanninoidea exitiosa*), Fig. 49. Unlike the borers already referred to, this insect is not the grub of a beetle, but the caterpillar of a moth. Next to the San José Scale, it takes rank as the worst enemy that the peach-grower has, and prior to the arrival of the scale destroyed more trees than all other causes combined. The parent moths are very pretty creatures; the male has a steel-blue body with



Fig. 49. Peach-tree Borer: 1, female moth; 2, male moth.

golden-yellow markings and clear transparent wings which expand about an inch; the female is considerably larger and totally different, the body being more than twice as thick, of a similar glossy steel-blue color, but crossed with a brilliant band of orange; the fore wings, which expand an inch and a half, are opaque and steely-blue like the body, while the smaller hind wings are transparent with a margin of scales of the same

steel-blue color. The moths are on the wing from about the beginning of July to the close of summer, as they do not all come out of the chrysalids at the same time. The eggs are laid in crevices on the trunk of the tree close to the ground, and the larvæ when hatched bore through the bark down towards the root; their presence is usually indicated by a mass of gum mingled with bits of bark and excrement which is exuded from the burrow. As the eggs are laid at different times during the summer, larvæ of all sizes may be found when winter sets in. During the cold weather they remain torpid in their burrows and complete their feeding and transformations in the spring.

All sorts of remedies have been tried for the destruction or the prevention of the attacks of this insect, but no thoroughly satisfactory one has yet been found. On the whole, the best plan is to carefully examine all the trees, one by one, and cut out with a sharp knife the worms whose presence is indicated by a mass of gum. This is a slow and therefore expensive operation. Wrapping tar-paper about the trunk and a few inches below the surface of the soil will keep the moths from depositing their eggs. Mounding up the base of the trees with earth is also done with the same object in view, but there is a danger of injuring the bark and therefore the health of the tree, if the earth is left too long against it. Washes of various kinds have been tried, but most of them are dangerous owing to the tender character of the bark; the only one that seems to be both effective and safe is gas-tar, the smell of which keeps away the moth. It should be used with care and tried on a few trees to begin with before applying to a whole orchard.

Among other insects affecting the Peach may be mentioned the Plum Curculio, which injures the fruit, and a black Aphis which often swarms on the leaves.

FUNGUS DISEASES AFFECTING THE PEACH.

PEACH LEAF-CURL (*Exoascus deformans*), Fig. 50. This disease usually becomes apparent early in the season, when it attacks both leaves and young shoots. The leaves become thickened and much distorted, and the edges curled, giving a characteristic appearance. When only small areas of the leaf are attacked, they become arched and pale yellow or reddish in color. When much of the leaf is involved, such a pronounced curling may be produced as to almost bring the edges of the leaf together. The color of the attacked parts varies from yellow to red. The fungus hibernates in the tissues of the tree and therefore reappears each year. Fallen leaves should be collected and burned; and those branches which bear diseased leaves should be pruned back beyond the point of infection and thus get rid of the perennial part of the fungus. Spraying with dilute Bordeaux mixture just when the leaf-buds are beginning to expand and again at an interval of three weeks will be found of much benefit.



Fig. 50. Peach leaf-curl,—affected foliage.

CROWN FUNGUS (*Dendrophagus*, sp.). Irregular shaped swellings usually about an inch in diameter situated generally at the crown of the root, but also on the younger roots. In some cases the swellings are as large as a man's fist. The outside of the gall is quite rough and irregular; the color at first is similar to that of the root, but later on becomes darker. It is a little softer and not so tough in texture as the normal root; in cross section it is somewhat spongy. This disease is spread in the nurseries, and nursery stock showing signs of the galls should be rejected. Removing infested trees is the only remedy.

THE PLUM SCAB (*Cladosporium carpophilum*) and the Brown Rot (*Sclerotinia fructigena*) of the Plum are often to be found affecting the Peach also. The Shot-hole Fungus (*Cylindrosporium padi*) of the Cherry is another of the occasional diseases of the Peach.

INSECTS AFFECTING THE GRAPE.

THE GRAPE-VINE FLEA-BEETLE (*Haltica chalybea*), Fig. 51. Among the numerous insect enemies of the Grape the first to appear in the spring is this Flea-beetle. It is a small steel-blue creature, sometimes metallic green or purple, about one-sixth of an inch long, with the thighs of the



Fig. 51. Grape-vine Flea-beetle.

hind-legs greatly enlarged, enabling the lively little insect to jump to some distance; hence the name "Flea-beetle." It winters in the adult stage under fallen leaves and other rubbish and comes out as soon as the weather is warm enough to cause the buds to swell. Upon these it feeds, boring into them and devouring them, and to such an extent that some-

times the canes have few leaves left. It soon begins to deposit its minute orange eggs in clusters on the underside of the foliage, and from these there hatch out small dark-brown grubs which eat holes through the leaves and sometimes completely devour them. About the end of June they are full grown, and enter the earth to transform to the pupal stage; two or three weeks later the new brood of beetles appears and feeds upon the foliage of the vine, which by this time is so luxuriant that it is not injured by the attack. Late in autumn the beetles betake themselves to their winter hiding-places.

The chief thing to do in dealing with this insect is to watch for it in the spring, and as soon as any are to be seen to spray or syringe with Paris green to which lime has been added. Another method is to jar the beetles from the vines into a pan of water with some coal-oil floating on the surface, or on a sheet soaked with the oil; this should be done when they are somewhat torpid in the early morning. During the warmer hours of the day they are too lively to be caught in this manner. Later on in the season, should the grubs be seen on the foliage the spraying should be repeated. In the autumn all fallen leaves and rubbish about the vines should be cleaned up and burnt so as to leave no convenient winter quarters for the beetle. As this insect is equally prevalent on the Virginia-creeper, the same treatment should be applied to it if there are any of these favorite plants near by.

THE ROSE-CHAFER (*Macrodactylus subspinosus*), Fig. 52. Later in the season, when the blossoms appear on the vines, another beetle, but of a different family, makes an attack upon them. It is commonly called the Rose-beetle or Rose-chaffer, from its habit of devouring the bloom of roses, but it is even a worse enemy of the grape, as it destroys the blossoms and with them all hope of fruit. Fortunately it is somewhat local, and is not everywhere a pest. During 1906 it appeared in great numbers in various places from the outskirts of Toronto, which seems to be its eastern limit at present, to the County of Essex; it has been abundant for some years in the neighborhood of London, but does not appear to extend much farther north.

The larva lives upon the roots of grasses in old pastures where the soil is sandy; it has not been found in clay land. The eggs are laid by the female an inch or two below the surface of the ground, and the young larvæ gradually grow to maturity during the summer and spend the winter in that condition, hibernating in a cell that they make somewhat deep down in the earth. In spring they work their way to the surface, transform to pupæ and emerge as beetles in June. This destructive stage lasts from three to four weeks. They appear suddenly in great swarms, completely covering the bloom that they attack, crawling and sprawling over each other and looking anything but attractive. Flowers of almost any kind are devoured by them, and they also carry their work of destruction to the partially formed apples. After being in profusion for about a month they disappear as suddenly as they came.

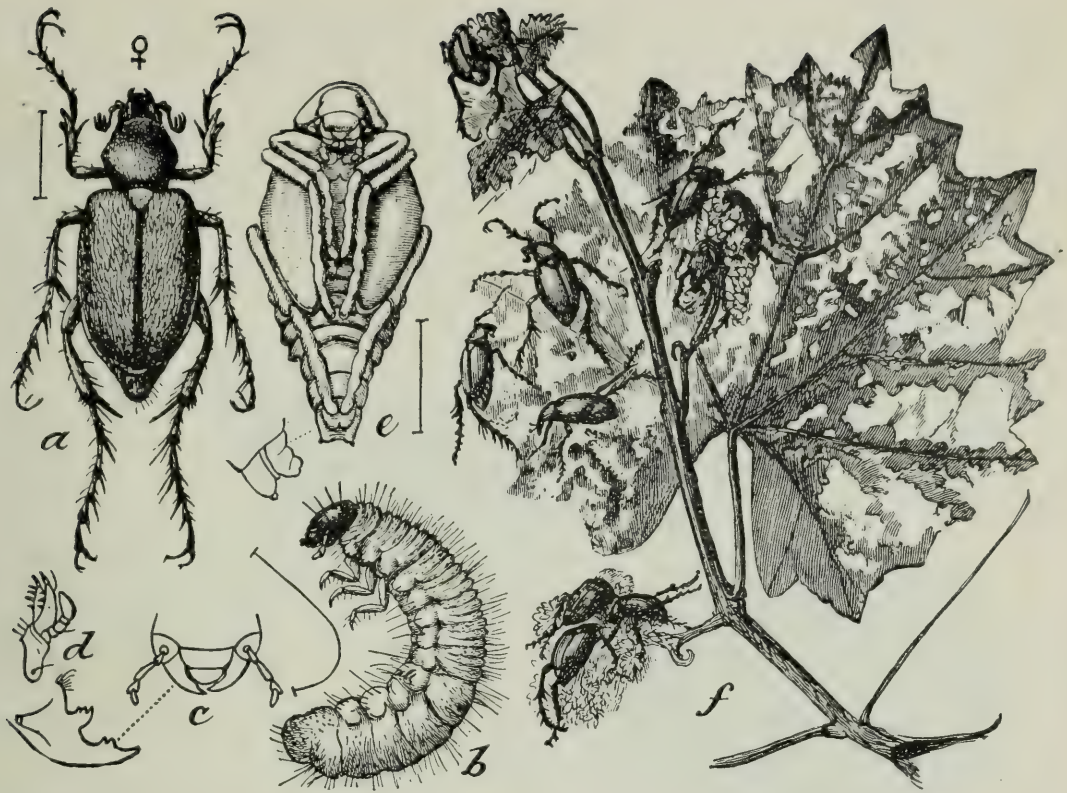


Fig. 52. Rose Chafer (*Macrodactylus subspinosus*); a, beetle; b, larva; c and d, mouth parts of same; e, pupa; f, injury to leaves and blossoms with beetles, natural size, at work (after Marlatt, U. S. Dept. Agriculture).

The beetle is of a dull yellowish brown color, half an inch long with very long, spiny legs, from which it gets its scientific name. It is a difficult creature to do anything with, as Paris green has little or no effect upon it. In gardens the best plan is to destroy the insect by hand-picking, or by jarring from the plants into pans containing a little coal oil; this should be done in the morning and evening when the beetles are not so lively as in the heat of the day. The breeding places, if they can be discovered, should be plowed up and planted with some crop. In any case no pastures should be allowed to remain long in grass, but should be treated in a regular rotation of crops as in the case of other fields; if let alone they gradually become the homes of May beetles or "June-bugs," wire-worms, and other destructive insects.

THE SPOTTED PELIDNOTA (*Pelidnota punctata*), Fig. 53. A third and very much larger beetle is to be numbered among the insects attacking the vine; it is a handsome creature, about an inch and a half in length, oval in shape, and very convex above. The head is black, the thorax somewhat bronzed, and the wing-covers clay-yellow with three black spots on each side; the under surface is dark metallic green. These beetles may be found upon the vines eating the foliage during July and August; they belong to the same family as the Rose-chafer and the May-

beetle, but fortunately do not appear in large numbers. The grubs feed upon rotten wood in decaying stumps and logs, and are not injurious in that stage.

Being so large and conspicuous, it is usually an easy matter to pick the beetles off the vines with the fingers and crush them under foot. They are chiefly to be found in the southern counties of Ontario, and are rarely seen east of Toronto.

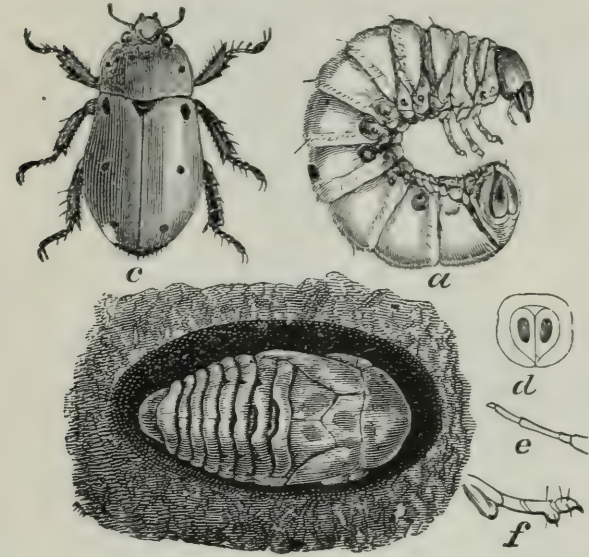


Fig. 53. The Spotted Pelidnota;
a, grub; b, pupa; c, beetle.

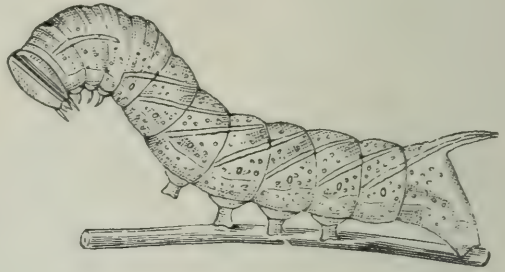


Fig. 54. Sphinx Caterpillar in
characteristic attitude.

GRAPE-VINE SPHINX CATERPILLARS. There are at least five different species of these insects to be found feeding upon the leaves of the grape in Canada. The most common is the Green Grape-vine Sphinx (*Darapsa myron*), which may be taken as a representative of the family. The young caterpillars, which are to be found in June, are of a pale yellowish color with a long blackish horn, or tail, near the posterior end of the body. With each moult the caterpillar changes somewhat in appearance and the horn becomes shorter. When full-grown it is quite two inches long, green in color, covered with small granulations, and adorned with a pale yellow stripe along each side; below this there are seven oblique yellow stripes, slanting backwards. The accompanying figure represents the caterpillar at this stage. (Fig. 54.) Occasionally individuals are to be found of a reddish or pinkish color with markings of a darker brown. The chrysalis is formed in a loose cocoon of leaves drawn together with silken threads at the base of the vine. A second brood of moths appears at the end of June, the caterpillars from which mature in September and spend the winter in the chrysalis state, from which the moth comes out in May.

The moth is a beautiful insect (Fig. 55), with long narrow fore-wings expanding about two inches and a half, of a velvety olive-green color, with darker bands across them; the hind wings are much smaller and

rusty red in color without markings. These insects are called Hawkmoths from their swift darting flight from flower to flower at dusk or early evening; they poise on swiftly vibrating wings, like Humming-birds, and suck the nectar from tubular flowers with their long, slender tongue, which coils up beneath the head like a watch-spring when not in use. The name Sphinx is derived from the attitude often assumed by the caterpillars, which hold up their head and front segments so as to present a fanciful resemblance to the mysterious Egyptian Sphinx. (Fig. 54.)



Fig. 55. Green Grape-vine Sphinx Moth.

The other species affecting the vine, the Achemon and the Abbot Sphinx, and the White-lined and Dark-veined Deilephilas, are very similar in their habits and their caterpillars feed in the same way. Being large and voracious, they sometimes entirely strip a branch of its leaves. They are kept in check by their parasitic enemies and seldom, therefore, appear in large numbers. As their presence can be detected by the denuded branches, or their large black or brown castings on the ground beneath, they can easily be got rid of by hand-picking. It is only on young vines that they are likely to prove very injurious; the foliage of the older ones is so luxurious that the loss of leaves in this way is hardly appreciable.



Fig. 56. Wood-nymph Moth.

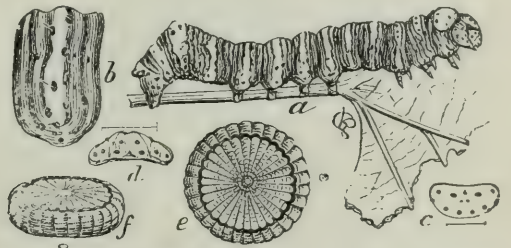


Fig. 57. Wood-nymph; *e* and *f*, eggs; *a*, caterpillar.

THE WOOD NYMPH CATERpillARS (*Eudryas grata* and *unio*), Figs. 56, 57. Occasionally the grape-vine is found to be severely attacked by scattered caterpillars of a bluish color. On close inspection they are found to be very prettily marked, each segment having an orange band crossing it in the middle and half a dozen black lines on the purplish-blue ground color; the segment behind the head and one near the tail are more con-

spicuously decorated with orange. The adult moths are very beautiful, with fore wings creamy white, broadly bordered with chocolate and olive-green, and the hind wings yellow with a narrow brown border; when at rest the densely scaled front legs are stretched out conspicuously and the wings folded together in roof-shape over the body. As soon as the caterpillars are observed they may be treated with Paris green. Though present on the vines every year, it is only once in five or six years that they are numerous enough to demand attention.

GRAPE-VINE LEAF-ROLLERS AND OTHER CATERPILLARS. A number of caterpillars of other kinds of moths feed also upon the leaves of the grape. As a general rule they are not particularly injurious, but they are liable at times to become so numerous as to require spraying with Paris green.

THE GRAPE-VINE LEAF-ROLLER (*Desmia maculalis*) is nearly always to be found on the vine and may be discovered by the leaves rolled up in cylindrical form which the larva inhabits. The moth is black with some white spots on the wings and white fringes—a beautiful little creature. There are two broods during the year. When disturbed the lively caterpillar drops instantly out of its case and falls to the ground; hand-picking is therefore difficult, but the increase of the insect may be checked by burning the leaves in the fall.



Fig. 58. Grape-vine Geometer; caterpillar and moth.



Fig. 59. A Cut-worm Caterpillar and Moth.

THE GRAPE-VINE GEOMETER (*Cidaria diversilineata*), Fig. 58, is a pale yellowish-green looper or measuring worm, which develops into a pretty yellow moth with fore-wings crossed and recrossed with darker lines. In June these caterpillars are sometimes numerous, but may soon be overcome by the Paris green treatment.

THE YELLOW WOOLLY-BEAR (*Spilosoma virginica*) will feed upon almost any kind of plant, but seems to particularly relish the leaves of the grape. The hairy caterpillar must be very familiar to every one. The moths are soft, pure-white creatures with a few black dots on the wings and orange bands and black spots on the body.

Several species of climbing Cut-worms (*Agrotis*), Fig. 59, attack the buds and foliage of the grape. They are nocturnal in their habits and are therefore not often seen upon the vines. During the night they come out of their hiding-places, climb up the vines and devour the leaves. The

best remedy for them is a mash of poisoned bran made by slightly moistening 25 pounds with water in which some sugar has been dissolved, and then adding 4 ounces of Paris green; the poison should be gradually dusted on the top and stirred all the time, otherwise it will sink through the bran at once and be ineffective. If bran cannot be obtained, flour may be used instead. A handful or two of the mash should be placed at the base of each vine. When the caterpillars come out they will eat this mixture in preference to anything else and then return to their hiding-places to die.

Many other caterpillars, great and small, feed upon the foliage of the grape, and may from time to time become destructive. Spraying with Paris green will get rid of them whenever they appear to be dangerous.

THE GRAPE LEAF-HOPPER (*Typhlocyba vitifex*). This insect is commonly, but erroneously, called "Thrips." It is a minute creature, about one-eighth of an inch in length, and is to be found in great numbers on the under side of the leaves. When disturbed it hops with great agility and quickly takes flight. When seen under a magnifying glass these insects are found to be prettily marked with different colors, red, yellow, etc., and are believed to represent several species. The larvæ appear in June and resemble the adults, except that they are smaller and wingless; they moult several times and the empty cast-off skins may often be found in great numbers sticking to the leaves. These insects belong to the order of true "bugs," and are furnished with beaks for sucking the juices of the plants, not with jaws for biting; consequently they cannot be poisoned through their food, but must be treated with contact remedies such as strong tobacco water, whale-oil soap or kerosene emulsion. Their presence is usually made known by the blotches they produce on the leaves from the exhaustion of the sap; and as they occur in immense numbers they often destroy the whole leaf, causing it to look as if scorched, and to drop from the vine. In winter the adults take refuge under leaves and rubbish, and may be destroyed, with several other of the insects here referred to, by raking up and burning all such material in the autumn.

THE GRAPE PHYLLOXERA (*Phylloxera vastatrix*), Fig. 60. In the wine-producing countries of Europe no insect has a more evil reputation or is more dreaded than this native American species, which has caused enormous losses to the vine-growers and almost destroyed the chief industry of many large districts in France, Spain, Portugal and other countries. Volumes have been written describing its history, habits, distribution and the remedies that have been tried for its control. Millions of dollars would not cover the losses it has entailed. Now, happily, it has ceased to be a serious pest, though it has by no means been exterminated. Relief was obtained in Europe by grafting their own varieties on American stocks which are able to resist the attacks of this insidious foe.

The insect has two forms, one living underground and attacking the roots, producing swellings or galls, which cause rotting and death of the roots, and therefore the loss of the whole vine; the other form attacks the leaves, covering them with small galls and causing their destruction.



Fig. 60. Phylloxera galls on a grape-leaf.

The life-history of the insect is a very remarkable one and may be found in most works on Economic Entomology; to fully describe it here would occupy more space than is available, and seems hardly to be necessary. The figure will serve for the recognition of the gall. The root-infesting form can be overcome by the use of bisulphide of carbon, but the better plan is to grow the resistant stocks on which the choicer varieties may be grafted.

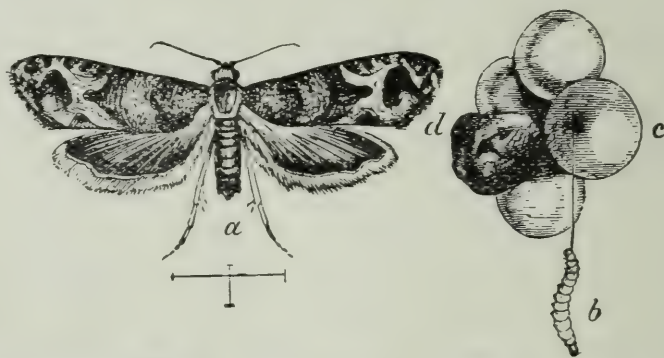


Fig. 61. Grape-berry Moth (magnified); caterpillar and affected fruit.

THE GRAPE-BERRY MOTH (*Eudemis botrana*), Fig. 61. When the grapes are approaching maturity, discolored berries here and there on the bunches may be noticed, and if carefully examined will be found to be inhabited by a small whitish-green larva, which feeds upon the pulp. After consuming the contents of one berry the worm attacks others and draws them together with silken threads mixed with its castings, thus

producing an offensive mass and greatly injuring the value of the whole bunch. When full grown it makes a case out of a portion of a leaf that it cuts for the purpose, and there passes through the chrysalis stage. The tiny moth is slate-blue in color with red-brown markings on the forewings. The winter, so far as known, is spent in the chrysalis stage, and therefore the insect may be destroyed by burning the leaves in the autumn. All fallen fruit should be regularly gathered up and fed to pigs or deeply buried in the earth. Where a few choice vines only are grown it will be quite worth while to cut out all discolored berries as soon as they are noticed and get rid of the worms before they have extended their injuries to others.

FUNGUS DISEASES AFFECTING THE GRAPE.

BLACK ROT (*Guignardia Bidwellii*), Fig. 62. Attacks both leaves and fruit of the Grape, producing conspicuous circular reddish brown spots on the former. The fungus causes the fruit to rot, the color at this stage being brown, but later on the berries become dried up, forming wrinkled, brownish or black, hard mummy-like bodies which adhere to the vine for some time. When the surface of the grape is examined closely it is found studded with innumerable small black dots, the fruiting bodies of the fungus. Spraying with Bordeaux mixture should begin about the first week in June or just before the blossoming period; the second application should be made about three weeks later, and the third about two or three weeks later still. Three thorough sprayings will keep the disease under control



Fig. 62. A cluster of grapes rendered worthless by Black Rot.

DOWNY MILDEW, or BROWN ROT OF THE GRAPE (*Plasmopara viticola*). This fungus attacks the leaves, petioles and young shoots, tendrils and fruit of the Grape. The disease first appears as yellowish spots on the upper surface of the leaves. These increase rapidly in size and number,

becoming brown as the infested tissues die, and on the under side mouldy or frost-like, being covered with a delicate white film. When badly attacked the leaves fall off in about two weeks, and in this way the vines frequently lose all their leaves, thus preventing fruit development, even if the clusters themselves are not attacked. The treatment for Black Rot is recommended for this trouble also.

POWDERY MILDEW (*Uncinula spiralis*). This fungus attacks leaves, young shoots and fruit; it appears as white or greyish mealy patches on the upper surface of the leaves and on the fruit. Towards the end of the summer the fruits become yellowish and finally almost black; the attacked grapes crack and ultimately wither up. The treatment for Black Rot will also keep the Powdery Mildew in check.

ANTHRACNOSE, or BIRD'S-EYE ROT (*Sphaceoloma ampelinum*). This disease is found on all green parts of the Grape, but more especially on the canes, where it appears as small brown marks which sometimes unite and form lengthened spots. When the berries are affected, they show brownish or blackish specks with a more or less circular outline; the centres of these become grey and surrounding this a conspicuous red ring with a dark border on the outside of it sometimes appears. Berries attacked do not wither or turn brown as those referred to in "Black Rot" or "Brown Rot," but the portion affected becomes somewhat wrinkled, and the berries assume an irregular shape. The spores pass the winter on leaves, fruit or shoots. Thorough spraying with Bordeaux mixture as for Black Rot will keep this fungus under control.

INSECTICIDES.

The following instructions for the preparation of the various insecticides referred to in these pages are those that on the whole have been found the most effective in practice. Experiences will no doubt differ and some prefer a variation in the quantities prescribed, but as already stated, a great deal depends upon the care which is exercised in the preparation and the skill with which it is applied. In this, as in other things, practice makes perfect, and a remedy should not be discarded because it has not proved absolutely effective on its first application.

A Bulletin recently prepared by Professor Harcourt and Mr. Fulmer of the Ontario Agricultural College and published by the Department of Agriculture, "Insecticides and Fungicides," Bulletin 154, should be procured and studied by every fruit-grower.

LIME-SULPHUR WASH.

This is made with 22 pounds of fresh lime, 18 pounds sulphur (flowers), and 40 gallons of water; another formula is 20 pounds of lime and 15 pounds sulphur. The sulphur should be made into a paste with warm

water and added to the lime, which is slaked in about 15 gallons of warm water with continued stirring. The mixture is then boiled for an hour and a half in a kettle, or better, in a barrel with live steam. It should be made up to 40 gallons with hot water, strained into a spraying tank and applied to the trees while hot. The quality of the lime is important; the Beachville and Port Colborne limes are very satisfactory, but those from the neighborhood of Guelph contain too much magnesia to be serviceable.

There are other methods of making the wash which will be found described in Bulletin 154.

SPRAYING REMEDIES.

PARIS GREEN AND BORDEAUX MIXTURE.

Four pounds of fresh lime, 4 pounds of bluestone, and 4 ounces of Paris green, thoroughly mixed in 40 gallons of water. In all cases where spraying with Paris green is recommended in the foregoing pages it is advisable to add the bluestone (or Bordeaux mixture) in order to counteract fungus diseases at the same time as the insects are destroyed. The bluestone (copper sulphate) should be dissolved by suspending it in a wooden vessel containing 4 or 5 gallons of water, and the lime slaked in another vessel; if lumpy, the lime should be strained through coarse sacking. Pour the bluestone solution into a barrel and half fill with water; dilute the slaked lime to half a barrel and mix the two together. The Paris green should be made into a paste with warm water, poured into the barrel and stirred thoroughly. The mixture is then ready for use. The addition of the lime prevents the poison from scorching the foliage.

KEROSENE EMULSION.

The following is the formula recommended by Dr. Fletcher (Central Experimental Farm Bulletin No. 52):

Kerosene (coal oil)	2 gallons.
Rain water	1 gallon.
Soap	$\frac{1}{2}$ pound.

Boil the soap in the water till all is dissolved; then, while boiling hot, turn it into the kerosene and churn the mixture constantly and forcibly with a syringe or force pump for five minutes, when it will be of a smooth, creamy nature. If the emulsion is perfect, it will adhere to the surface of glass without oiliness. As it cools it thickens into a jelly-like mass. This gives the stock emulsion, which must be diluted with nine times its measure of warm water before using on vegetation. The above quantity of three gallons of emulsion will make 30 gallons of wash.

Kerosene emulsions may also be made conveniently by using an equal amount of sour milk instead of the soap and water in the above formula, and churning for the same time to get the stock emulsion.

Another method is to use lime, which will hold the kerosene in suspension, or the following, where lime cannot be obtained :

The requisite amount of kerosene is placed in a dry vessel and flour added in the proportion of 8 ounces to one quart of kerosene. It is then thoroughly stirred and two gallons of water added for every quart of kerosene; the whole is then vigorously churned for from two to four minutes, and the emulsion is ready for use. It has been found that by scalding the flour before adding the kerosene, an excellent emulsion which does not separate in the least after standing for a week, can be prepared with 2 ounces of flour, by mixing the resulting paste with one quart of kerosene and emulsifying with two gallons of water.

TOBACCO WASH (for destroying Aphis).

Soak 4 pounds of tobacco waste in 9 gallons of hot water for four or five hours (in cold water for four or five days); dissolve one pound of whale-oil soap in one gallon of hot water; strain the decoction into the dissolved soap and apply with a spray pump as forcibly as possible.

SOAP WASHES.

Dissolve one pound of whale-oil soap in four gallons of warm water for black or brown Aphis, and one pound in six gallons for green Aphis.

Another remedy for Aphis is the following : Boil 8 pounds of quassia chips in 8 gallons of water for an hour, dissolve 7 pounds of whale-oil soap in hot water; strain the quassia decoction and mix with the soap solution; then dilute to make 100 gallons. Spray forcibly while hot; this will kill the plant-lice and not injure the trees.

FUNGICIDES.

BORDEAUX MIXTURE.

This is made with four (or six) pounds of copper sulphate (bluestone) and four pounds of fresh lime thoroughly mixed in 40 gallons of water. The larger quantity of bluestone is recommended by many practical fruit-growers, as an equal amount of lime causes the mixture to act more slowly, and to be more liable to clog the machinery. In a wet season it may be of advantage by causing the mixture to retain its efficiency longer. The best quality of quicklime should be used.

In many cases it is better to use the poisoned Bordeaux mixture, which is made, as described above, by the addition of four ounces of Paris

green. This will destroy many kinds of injurious insects as well as fungus diseases.

Test the Bordeaux to find out whether sufficient milk of lime has been added. This is most easily done by means of the ferrocyanide test. A saturated solution of this substance can be purchased at any druggist's for a few cents. In testing, place some of the Bordeaux, which has been thoroughly stirred, in a saucer, and add a few drops of the ferrocyanide. If sufficient lime has been used, no discoloration will appear, but if insufficient, a deep, dark brown color will be produced.

AMMONIACAL COPPER CARBONATE.

This fungicide is useful for application to trees when the fruit is well advanced and might be disfigured by the employment of Bordeaux mixture. The following are the materials used: 5 ounces of copper carbonate, 3 pints of ammonia, and 45 gallons of water. For instructions regarding the preparation of these materials see Bulletin No. 154.

In the foregoing pages descriptions and figures are given of the injurious insects that are commonly found upon fruit-trees. If the reader should meet with others regarding which he desires information, he is requested to send specimens to the Department of Entomology, Ontario Agricultural College, Guelph, and to mention any particulars that he may have observed. Immediate attention will be given to the enquiry and the specimens will be reported upon with any information or advice that can be offered. Living specimens should be enclosed in a small tin or wooden box, with some of the plant upon which they are found; it is not necessary to make any holes for the admission of air. Dried and fragile specimens should also be sent in strong cardboard or wooden boxes to prevent their being crushed in the mail. If the packet is marked "Entomological Specimens," the postage is one cent for two ounces.

Specimens of fungus diseases may be sent in paper or cardboard boxes; the postage on them is that of fourth class matter, viz., one cent per ounce. Twigs, blossoms or foliage may be sent as "Botanical Specimens" at one cent for four ounces.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE

MILKING MACHINES.

BY H. H. DEAN, PROFESSOR OF DAIRYING.

The milking of cows by machinery is a very live topic at the present time among dairymen. Having had considerable experience with these machines, we may be allowed to discuss the matter briefly. All our spare time for experiments in the dairy stable during the past year has been devoted to a study of the problems connected with the milking of cows by machinery. We shall consider the question from three viewpoints, viz., physiological, mechanical, and practical operation of the machines. We shall also give results of experiments made this year.

Under physiological, we may first look at the various theories which have been propounded in order to explain the secretion of milk. The problem is a very complicated one, and no very satisfactory explanation of milk secretion has yet been offered. One theory says it is the result of changes in the cells which go to make up the organ of the cow known as the udder. In other words, according to this theory, milk is the liquefied cells which largely compose the mammary glands. The chief objection to the metamorphic or change theory is that a cow giving a large quantity of milk would have to build up the cells of the udder several times during a day, which is practically impossible for her to do.

The second theory is known as the transudation or filter theory, which assumes that milk is merely filtered from the blood by the mammary glands. The chief objection to the filter theory is that blood and milk are not of the same composition. There are substances found in the milk which are not found in the blood, e.g., casein, which is probably the result of cell action. If we combine the metamorphic and transudation theories regarding milk secretion we shall probably have the most satisfactory explanation of the mysterious process of milk secretion.

There is also the ferment theory, which ascribes the secretion of milk to the action of ferments in the cow's udder. We are not inclined to favor this theory, although it may explain some of the phenomena in connection with milk secretion.

There is nothing in the physiological processes so far as we can see, to prevent the satisfactory milking of cows by machinery, and we have always had faith that such a machine would become practicable. Nearly all modern milking machines have been operated on the principle of suction, or have imitated the milking of cows by calf sucking. We have

to bear in mind that all the large milk records have been made by *hand* milking. The development of dairy cows to their present large production has been done by a process of hand milking and not by suction. It is possible that inventors of suction milking machines have been working on a wrong principle. Who can tell? It is a fact that a non-suction milking machine has recently been invented in New Zealand, whose promoters say that it is the only correct principle for milking cows. Who can tell if this be so? It will require years of experience to determine which type of machine will prove most satisfactory, and whether or not machine milking is practicable.

Fleischmann, a German authority, says: "It is only those who are entirely ignorant of the nature of the milking operation who can abandon themselves to the idea of using milking machines of any description."

Mechanical Problems. A milking machine to be popular must be simple, cheap, durable, easily cleaned, require a minimum amount of power, time, and labor to operate it, and one person must be able to milk from four to six cows at once with the machine. While not wishing to disparage any manufacturer of milking machines, we must say that nearly all the machines which have been put on the market up to the present have been too complicated for the average man to operate. They are also too expensive for small farmers, and some of them have required altogether too much power, time, and labor to operate them. One, at least, of those who have tried was impossible to keep clean. However, we have faith in the ultimate triumph of mechanical skill over the many difficulties connected with the problem of milking cows by machinery.

PRACTICAL EXPERIENCE WITH THREE TYPES OF MACHINES.

Our first experience in 1895 was with the "Murchland" suction, non-pulsating machine, operated by means of a hand vacuum pump. After working with this machine for some time we gave it up. The chief difficulties were in maintaining a uniform vacuum which resulted in the cows not being milked out clean, consequently they gave less milk and milk containing a lower percentage of fat, as compared with hand milking.

Our second experience was with the "Thistle" milking machine, which also operated on the suction principle, but combined a double action, viz., sucking and squeezing of the teat. In other words, this machine aimed to combine the motions of calf sucking and hand milking. For a time we got very good results, and it seemed as if the problem had been solved. However, when hot weather came we found an odor in the milk which tainted it so badly that we were forced to give it up. By some means or other, milk was drawn into the vacuum pipes and when this milk began to decay the odor was very bad. As there was no way of cleaning these pipes, except by taking the pipes down each time, which was not practicable, we gave up the "Thistle" and laid it on the

scrap heap. Another serious objection to this machine was the large amount of power required to operate it.

There was a lull in milking machines at our College for nearly ten years—1895 to 1905. This was partially filled in with a hand milker invented in England, which milked four teats at once by pressing the teats against a rubber surface by means of revolving rollers covered with rubber. This was impracticable, because all cows' teats are not of the same size, nor do they hang perpendicularly and evenly from the udder. With a perfectly shaped udder and all teats the same shape and size, the machine might work. This, too, was laid on the scrap heap.

The "Calfette" milker was tried during the summer of 1906, but was not satisfactory.

In December, 1905, we installed a Burrell-Lawrence-Kennedy eight-cow milker. We began using the machine January 1st, 1906, and have used it during most of the past year. Of all the machines we have tried, this has been the most satisfactory, and yet it is far from perfection. The Burrell-Lawrence-Kennedy (B-L-K) milking machine works on the pulsating, suction plan, i.e., a vacuum is created by means of a double acting vacuum pump, which in our case is driven with an electric motor. However, any kind of power may be used for driving the pump. The estimated power required to milk eight cows at once is about $1\frac{1}{2}$ to 2 horse power. The vacuum created for milking the cows is equal to about 16 inches of mercury, or about half the pressure of the atmosphere. The pump is connected by means of galvanized iron pipes with the stalls where the cows are milked. Between each pair of cows is located a stopcock, which is connected to the milker by means of about four or five feet of ordinary rubber hose. The pulsating apparatus sits on the milk pail, and in this respect differs from the "Thistle," in which the pulsating took place at the machine, consequently a great deal of power was required to operate it. The pulsations are obtained by an ingenious device for allowing air to enter, thus reducing the vacuum, but not sufficient to allow the cups to drop off the cows' teats. The milker, having the pulsator on top and a receptacle like a milk pail below, is connected with the cows' teats by means of a rubber tube on which are four branches near the end farthest from the milker. The four branches have each a cone-shaped metal teat cup at the end, covered with a rubber mouth-piece having an opening in the centre for admitting the cow's teat. A "sight glass" on top of the milker enables the operator to see when the cow is finished and whether or not she is "giving down" her milk.

A stopcock on the milker connects the milker with the cows' teats by means of the teat cups, which latter are of different sizes to accommodate different sized teats. The pressure of the atmosphere having been removed from the outside of the cows' teats, the milk begins to flow because of body or blood pressure on the milk formed in the udder. This seems to be the weak point. With most cows the milk starts to flow freely and to the casual observer everything appears to be all right. To the close

observer, however, there is a defect. After leaving the machine on for some time after the milk ceases to flow, the careful milker notices in many cases that the udder is still somewhat tense and that the cow has not given her usual flow of milk. In some cases, and particularly with some cows, all the milk is removed in a very short time, and there is practically no "strippings." In many cases after removing the machine, the ordinary person would declare the cow to be milked out clean, but a little patience will often enable the milker to get from 3 to 10 pounds, or even more, of "strippings." This, of course, is very bad for the cows. If these "strippings" be not removed it tends to cause the cows to "dry up" much sooner than usual. To overcome this, the manufacturers recommend "manipulating the udder" in order to induce them to "let down" their milk. From close and careful observation on our own herd, we feel quite sure that "manipulation of the udder" does little or no good, and in most cases does harm, although we have followed this plan during most of the year because the makers of the machine seemed so confident that this was very essential.

Our reasons for thinking that "manipulation" is of little or no value are that close watching of the cows at the time when "manipulation" commences, enables us to see a contraction of the muscles of the abdomen, which muscles are connected with those closing the numerous milk ducts, and so far as we have noted, with very few exceptions, the milk flow is not increased by "manipulation." A gentle pulling downward on the cups tends to secure the last of the milk, but in most cases we have found hand stripping necessary. There was a time when it seemed as if hand stripping would not be necessary. Soon after July 1st, the cows began to fail so much in their milk, although the pastures were excellent, that we were obliged to resort to hand stripping, and in the case of some cows to milk them altogether by hand, in order to prevent them drying two or three months before they ought. How much these results were due to visitors it is difficult to say.

Before closing these general observations, we think the whole situation may be summed up in the words of our herdsman, Mr. Wood:—"The machine will milk the cows all right, *if the cows will give down their milk.*" Here we have the whole question in a nut-shell. If the cows in our herd represent the attitude of the majority of cows towards the milking machine, as we have it to-day, then we must conclude that it is not altogether satisfactory, as there is no known way of compelling to give down her milk if she will not voluntarily do so.

As previously stated, we began using the "B-L-K milkers" on January 1st, 1906. In order to see whether or not the milk flow and percentages of fat were affected to any extent by the change from hand to machine milking, we have made a table showing the comparative yields of milk, percentages of fat, and pounds of milk fat given by fifteen cows during the months of December, 1905, when the cows were milked by hand, and the month of January, 1906, when they were milked with the

machines. During December each milking from each individual cow was weighed, and sampled for testing. The composite sample made up of the individual daily samples, was tested at the end of the month, and the pounds of milk fat were obtained by multiplying the pounds of milk given by each cow by her test and dividing by 100, e.g., cow No. 15 gave 952 pounds of milk during December. Her composite test was 3.4, and 952 multiplied by 3.4 divided by 100 equal 32.36 pounds fat.

During January each cow's milk was weighed morning and evening and samples were taken for testing every seven days. The pounds of milk and milk fat were calculated from these weights and tests, hence are not so accurate as for December.

Table Showing Comparison of Yields of Milk and Milk Fat for December, 1905 (hand milking) and January, 1906 (machine milking).

No. of Cow.	Lbs. Milk.		Per cent. Fat.		Lbs. Milk Fat.		Increase (+) or decrease (—) of machine compared with hand milking for one month.		
	Dec. '05.	Jan. '06.	Dec. '05.	Jan. '06.	Dec. '05.	Jan. '06.	Lbs of milk.	% of fat in milk.	Lbs. milk fat.
15	952	808	3.4	3.0	32.36	24.24	— 144	— 0.4	— 8.12
21	900	727	3.8	3.8	34.20	27.62	— 173	+ .00	— 6.58
28	461	406	4.5	4.7	20.74	19.08	— 55	+ 0.2	— 0.66
38	1,037	753	3.8	4.0	39.40	30.12	— 284	+ 0.2	— 9.28
44	473	418	3.6	3.4	17.02	14.21	— 55	— 0.2	— 2.81
56	1,707	1,508	3.8	3.7	64.86	55.79	— 199	— 0.1	— 9.70
65	427	416	3.8	4.0	16.22	16.64	— 11	+ 0.2	+ 0.42
66	542	483	4.1	4.3	22.22	20.76	— 59	+ 0.2	— 1.46
67	713	572	3.3	3.6	23.52	20.59	— 141	+ 0.3	+ 2.93
70	518	475	5.4	5.7	27.97	27.07	— 43	+ 0.3	— 0.90
78	581	548	3.8	4.2	22.07	23.01	— 33	+ 0.4	+ 0.94
96	402	403	3.7	4.0	14.87	16.12	+ 1	+ 0.3	+ 1.25
97	503	455	4.6	4.7	23.13	21.38	— 48	+ 0.1	— 1.75
98	329	273	4.7	4.7	15.46	12.83	— 56	+ .00	— 2.52
103	431	380	3.7	3.5	15.94	13.30	— 51	— 0.2	— 2.64
Totals and Averages..	9,976	8,625	3.90	3.97	389.98	342.76	—13.57	+0.07	—47.22

From the preceding table we learn that these fifteen cows gave 1,351 pounds less milk in January, 1906, than they did in December, 1905. The percentages of fat were fairly constant, though the tendency was for a slightly higher average test for January (3.97) as compared with December (3.90). The pounds of milk fat, however, decreased 47.22 pounds in January as compared with December. If we allow an increase of one-sixth on the fat for calculating the butter, the decrease in butter on the

fifteen cows is 55 pounds., or over $3\frac{1}{2}$ pounds butter per cow for the month. Some of this may be due to an advance in lactation, or some to errors in calculation, but the evidence seems to point very strongly towards quite a marked decrease in milk and butter during the first month after the installation of the machines. However, we should expect a decrease with most cows after making so radical a change, as from hand milking to a method new and strange to the cows.

SPECIAL TESTS COMPARING HAND AND MACHINE MILKING.

From time to time during the past year special trials comparing hand and machine milking have been made. These tests, however, were not altogether satisfactory, as it is almost impossible to get an exact comparison. There is no way of ascertaining what a cow *might have given* under other circumstances and conditions. The most we could do was to keep feed, water, temperature of stable, etc., as nearly alike as possible during the periods of tests, and assume that any differences in milk yield were due to methods of milking. This may or may not have been correct, but it was about the only thing which we could do under the circumstances. While most of these tests were for but short periods of time, the difficulties of comparison are even greater when we compare one lactation period with another. How can we say that differences in milk yield for one lactation period as compared with another are due to methods of milking or to any other *one* factor? We may *think* and say it is so, but it would be very difficult to prove our assertion.

For the sake of comparison, we give the results of some of these tests which have been made during the year. The machine was installed during the last weeks of December, 1905, and we began using it January 1st, 1906. It was thought advisable to allow the cows at least one month to become accustomed to the machine before making any special tests.

The first comparison was made on four cows, Nos. 15, 56, 106, and 107, beginning February 1st, 1906. The milk of each cow was kept separate, weighed and sampled for testing with the Babcock test every seven days for the two weeks. From February 15th to 28th, inclusive, these four cows were milked by hand. The milk from each was weighed and sampled daily for the two weeks. From March 1st to 14th the same cows were milked with the machine. Milk was weighed and sampled same as for the previous machine milked period. If we average the machine period before hand milking, with the machine period after hand milking, we shall balance as nearly as can be the effects of the period of lactation.

The following table shows the average yields of milk and fat for the two machine periods and also for the period of hand milking:—

Table Showing Comparison of Yields from Machine and Hand Milking for two-week periods in February and March.

No. of Cow.	Average for 2 periods of machine milking.		One period of hand milking.		Gain (+) or loss (—) in 2 weeks hand milking.	
	Lbs. Milk.	Lbs. Fat.	Lbs. Milk.	Lbs. Fat.	Lbs. Milk.	Lbs. Fat.
106	629	20.38	656	22.96	+ 27.0	+ 2.58
107	450	16.17	485	18.43	+ 35.0	+ 2.26
56	567	20.39	558	20.64	— 9.0	+ 0.25
15	289	8.59	315	10.39	+ 26.0	+ 1.80
Average of each of 4 cows for two weeks..	483.7	16.38	503.5	18.10	+19.75	+ 1.72

The foregoing table indicates a gain in pounds of milk for the hand milking in three out of four cows amounting to 79 pounds milk in 14 days, or an average of 19.7 pounds per cow in two weeks. Each and all of the four cows gave an increased amount of fat during the period when milked by hand amounting to a gain of 6.89 pounds milk fat in 14 days, or an average of 1.72 pounds fat per cow, which is equal to about 2 pounds butter per cow for the two weeks. Was this apparent gain due to hand milking or to some other factor or factors?

A similar experiment was made from March 30th to May 10th, with cows Nos. 15, 56 and 76. From March 30th to April 12th, inclusive, the cows were milked with the machine. Milk was weighed separately from each cow every seven days, and composite samples were taken every seven days for testing with the Babcock test. From April 13th to 26th these three cows were milked by hand, milk was weighed and sampled daily. From April 27th to May 10th, inclusive, they were milked with the machine.

Averaging the two machine periods, same as in the previous experiment, and comparing the results with the hand milking, we find that the average of the two periods where the three cows were milked by the machine, was 1,085 pounds milk and 34.8 pounds fat for the three cows in 14 days. During the fourteen days when milked by hand the same cows gave 1,005 pounds milk and 33.71 pounds fat. Apparently at this time these cows, two of which were the same as were used in the previous experiment, gave 80 pounds more milk and 1.9 pounds more milk fat when milked by the machine than they did in two weeks when milked by hand. But again we may reasonably ask, was this difference due to methods of milking or to something else?

COMPARISON OF MACHINE AND HAND MILKING FOR A TWO-WEEK PERIOD
WHEN COWS WERE ON GRASS.

From September 5th to 18th, inclusive, all the cows were milked by hand. For two weeks previous to this, and for two weeks after, the record of four of the cows milked regularly by hand is given, for comparison with the records of seven cows milked with the machine for two weeks previous to hand milking and for two weeks after hand milking. No special tests were made of the fat content of the milk. If we average the periods before and after hand milking, we shall eliminate so far as possible the effects of lactation. The yields of milk for the machine milked cows are calculated in periods one and three by averaging three weighings and multiplying the results by fourteen to obtain the pounds of milk given in two weeks. In period 2, for the machine milked lot, and in all three periods for the hand milked cows, the milk from each cow was weighed morning and evening, daily.

The table shows the weights of milk given in all three periods by both lots of cows.

*Comparison of Hand and Machine Milking, August, September, and
October, 1906.*

Cows.		Period 1. Aug. 27 to Sept 4	Period 2. Sept. 5 to Sept. 18.	Period 3. Sept. 19 to Oct. 2.	Av. 1 and 3. (Hand milk- ing, Group 1; machine milk- ing, Group 2.)	Gain (+) Loss (-) in Period 2.
GROUP 1.						
No. 106	Regularly milked by hand.	311	259	221	266	— 7
" 98		251	221	205	228	— 7
" 122		361	306	261	311	— 5
" 101		131	114	117	124	—10
	Totals	1,054	900	804	929	—29
GROUP 2.						
No. 69	Regularly milked with machine except in Period 2.	252	225	217	234.5	— 9.5
" 86		287	277	231	259	+18
" 90		378	365	326	352	+13
" 78		553	528	470	511.5	+16.5
" 87		370	386	326	348	+38
" 102		322	292	252	287	+ 5
" 70		357	320	284	325.5	— 5.5
		2,519	2,393	2,106	2,317.5	+75.5

When we compare the four cows regularly milked by hand, averaging periods 1 and 3 for comparison with period 2, we find that they all

were slightly lower in the second period, during which period the cows usually milked with the machine were milked by hand. The seven cows regularly milked with the machine gave $75\frac{1}{2}$ pounds more milk during the period when milked by hand as compared with the average of the two periods when milked with the machine. Five of the cows gave more milk by hand milking and two gave less, although the increase on the group of seven cows was about $7\frac{1}{2}$ gallons of milk in the two weeks when milked by hand as compared with the average of two weeks milked with the machine.

About the middle of October, 1906, we wrote the manufacturers of the milking machine, saying we were not satisfied with the results we were getting, and requested that they send one of their experts to operate the machines to see if improvements could be made. He came and stayed a week with us. His main suggestion was to "manipulate the udder" more than we had been doing. To follow his plan means that a man could not look after more than one or two machines, and would not be able to milk more than two to four cows at once. As a result of his work the cows appeared to milk out cleaner than they had been doing, i.e., there was less "strippings" from them than usual, but the question arose whether this was due to "cleaner milking" or to a condition which prevented the hand milker obtaining the "strippings." In order to test this point so far as possible and also to compare ordinary and expert running of machines, also ordinary and expert hand milking, a series of tests were made, beginning October 16th. The chief points in the experiments with ten cows are shown in the table, Machine vs. Hand Milking for Short Periods. These tests were made chiefly to see whether "manipulation" enabled the milker to get all of the milk or prevented strippings being got afterwards by hand. Also a comparison of expert and experienced milkers :—

On October 16th the ten cows were milked by the machines operated by our regular men. Next day, October 17th, half of the cows were milked by an expert hand milker and the other half by a milker who had had little experience milking cows. All the cows milked by the expert hand milker increased from 3 to 7 pounds milk per cow, or a total of 23 pounds milk in one day from the five cows. The other five cows milked by an inexperienced person gave practically the same quantity of milk by hand as with the machine on the previous day. Two of the cows gained a pound each, but this is no more than may occur any day.

On October 18th these ten cows were milked with the machines operated by the expert. Most of them were down in their milk as compared with the previous day when milked by hand. The totals for the ten cows were 248 pounds by hand and 226 pounds by expert machine milking. The totals on the 16th from our regular men operating the machines was 223 pounds. It would seem as if the expert operator got more milk (3 pounds) than did our regular men, but the quantity of milk was less than was obtained by hand milking.

As there was practically no "strippings" after the expert "manipulation" of the udder, are we to conclude that "manipulation" secured all the milk, or that it brought about a condition which prevented the hand milker from securing the "strippings"?

Date 1906.	Method of Milking.	No. of Cow.									
		78	90	66	96	97	69	86	87	102	70
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Oct. 16	Regular men operating machine	30	23	30	18	26	17	19	21	17	22
	Expert hand milking	36	26	33	22	33					
" 17	Inexperienced hand milking						17	19	22	18	22
" 17	Machine operated by expert	33	25	30	19	27	15	18	20	18	21
" 19	Inexperienced hand milking	35	24	28	19	27					
" 19	Expert hand milking						17	20	23	20	23
" 20	"	36	27	33	20	32					
" 20	Inexperienced milker						15	19	19	19	22
" 21	"						16	19	21	19	22
" 21	Expert milker	36	27	32	21	31					
" 21	"	36	27	33	22	32					
" 22	Inexperienced milker						15	20	20	20	22
" 22	{ A.M. machine	34	25	31	21	31	14	19	20	19	21
" 23	{ P.M. hand milking										
" 24	Reg. men operating machine	33	24	31	21	31	14	18	20	19	21
" 30	Reg. men operating machine	28	22	28	17	27	15	16	18	15	19

On October 19th those cows usually milked by the expert hand milker were milked by the inexperienced milker, and the expert milker milked those usually milked by the inexperienced person. The table shows that of the cows milked by the inexperienced milker one cow increased two pounds, two were the same as on the previous day milked with the machine, one cow gave one pound, and another two pounds, less milk by hand than with the machine. All the cows milked by the expert milker gave more milk by hand than they did the previous day when these cows were milked by an expert operating the milking machine. The total pounds of milk given by the ten cows on October 18th was 226 pounds, when the machines were operated by an expert. On October 19th, when hand milkers were changed, the total pounds milk were 236—an apparent increase of ten pounds as a result of hand milking.

On October 20th hand milkers were again changed. The expert hand milker got 148 pounds milk from his five cows, and the inexperienced milker got 94 pounds from his cows. On the 19th, with a change of hand

milkers, the results were 133 and 103 pounds respectively. The previous day (18th) when these cows were milked with the machine operated by an expert the weights of milk were 134 and 92 pounds, from the two groups respectively.

The table shows the result from hand milking for the 21st and 22nd, in which the quantity of milk remained fairly uniform for each cow, though there was a tendency towards an increase. On October 23rd these cows were milked in the morning with the machine operated by our own men, and in the evening by hand. The general tendency for the day was downward. The total pounds of milk given by the ten cows on October 22nd, when hand milked, was 247 pounds. Next day when milked in the morning with the machine, and in the evening by hand, the total pounds of milk were 235, an apparent loss of 12 pounds on the ten cows. On October 24th, all these ten cows were milked with the machine operated by our own men. The total yield of milk for the day was 232 pounds—another drop of three pounds from the previous day. The cows were now milked regularly with the machine, two cows in one pail in the usual way, until October 30th, when they were milked separately, and the milk weighed morning and evening. Nine out of ten of the cows gave less milk than they did October 24th. The total yield for the day was 205 pounds—a drop of 27 pounds from the previous weighing on October 24th. At this weighing special note was made of the weight of “strippings” given by each cow after milking as dry as possible with the machines. Three cows gave no “strippings” after the machine either morning or evening; four cows gave from one to two pounds of strippings at night; two cows gave 1 pound of “strippings” each at both night and morning milkings; and one cow gave 5 pounds in the morning and 3 at night in the form of “strippings,” out of a total yield for the day of 27 pounds milk for this one cow.

We are aware that these frequent changes from hand to machine milking, and change of milkers by hand, is not good for the cows, but we considered this was about the only way to get some data on the points at issue. The evidence all seems to point in the direction of greater milk yields by hand, but not much difference between inexperienced hand milking as compared with the machine. The weight of evidence also seems to indicate that “manipulation” of the udder tends to prevent the securing of the strippings by hand milking. However, this is a point very difficult to determine.

MACHINE VS. HAND MILKING DURING OCTOBER AND NOVEMBER, 1906.

From November 1st to 15th, inclusive, ten cows in the herd were milked by hand. From November 16th to 30th, inclusive, they were milked by machine. In order to compare the milking previous to and after hand milking with the fifteen days of hand milking, we have calculated the yield of milk for the last fifteen days in October based on two weighings made

the latter part of October, and using the monthly test for October in calculating the pounds of fat. This is not strictly correct, but is near enough for the purpose of comparison. During the last fifteen days of November the cows were milked individually with the machine and the weights and samples of milk were taken daily through the half month, the same as in hand milking. This plan gives a more exact method of comparison.

Table Showing Relative Yield of Milk and Fat for Two-week Periods during October and November, of ten cows.

No. of Cow.	Machine Milking, 15 days, Oct. (calculated.)			Hand Milking, Nov. 1-15th.			Machine Milking, Nov. 16-30th.		
	Lbs. M.	% Fat.	Lbs. Fat.	Lbs. M.	% Fat.	Lbs. Fat.	Lbs. M.	% Fat.	Lbs. Fat.
66.....	442	3.5	15.49	429	3.6	15.44	382	3.4	12.98
69.....	217	3.3	7.18	220	3.6	7.92	201	3.5	7.03
70.....	300	5.1	15.30	301	5.	15.05	263	5.2	13.67
78.....	457	3.	13.73	517	3.2	16.54	470	3.1	14.57
86.....	255	3.4	8.67	294	3.6	10.58	271	3.6	9.75
87.....	285	3.1	8.84	311	3.2	9.95	267	3.1	8.27
90.....	345	3.	10.35	378	3.2	12.10	344	3.0	10.32
96.....	285	3.9	11.12	288	3.8	10.94	262	3.6	9.43
97.....	435	4.2	18.27	435	3.8	16.53	359	4.0	14.36
102.....	255	3.7	9.44	268	3.7	9.92	238	4.0	9.52
Totals and averages..	3,276	3.61	118.39	3,441	3.54	124.97	3,057	3.59	109.92

The foregoing table shows an increase of 165 pounds milk and 6.58 pounds fat for the ten cows in the two weeks when milked by hand, from November 1st to 15th, inclusive, as compared with the previous fifteen days in October when milked with the machine. From November 16th to 30th, when milked with the machine, these ten cows gave 384 pounds less milk and 15.05 pounds less fat than they did the previous fifteen days when milked by hand.

If we average the milk and fat yields for the last fifteen days of October and the last fifteen days of November, we get 3,166 pounds milk and 114.14 pounds milk fat as the average production of the ten cows during fifteen days when milked with the machine. Comparing this with the intermediate period, November 1st to the 15th, when milked by hand, we have a difference of 275 pounds milk and 10.83 pounds fat, in favor of hand milking, for the ten cows in fifteen days.

The average percentages of fat were practically the same in all three periods.

In order to compare machine milking with experienced and inexperienced hand milkers, two of the ten cows were milked by a hand expert for the first eight days of November and two others were milked by an inexperienced person. At the end of eight days, hand milkers were reversed for seven days, i.e., the expert took the two cows milked by the inexperienced person and the inexperienced person took those milked by the expert. For the last fifteen days of November these cows were milked with the machine and each milking was weighed separately from each cow. The table shows that the average daily yield was increased by the expert during the second week by over two pounds daily with one cow and seven-tenths of a pound daily with the other. The two cows milked the first week by the expert and the second week by an inexperienced milker showed a loss of one pound of milk daily with one cow and practically the same with the other when milked by the inexperienced milker.

During the next two weeks, when these four cows should have maintained their milk flow, the results were downward with all four cows when milked with the machine.

Table Showing Daily Yield of Four Cows from Expert and Inexperienced Hand Milkers and Machine Milking, November, 1906.

Milker.	Cow 86.	Cow 87.	Cow 78.	Cow 90.
	Lbs.	Lbs.	Lbs.	Lbs.
Inexperienced hand milker, November 1-8.....	18.5	20.4		
Expert hand milker, November 1-8.....			34.4	25.7
Expert hand milker, November 9-15.....	20.8	21.1		
Inexperienced hand milker, November 9-15.....			34.5	24.7
Machine milking, November 16-23.....	18.7	18.7	32.5	23.2
Machine Milking, November 24-30.....	17.3	16.8	30.	32.5

ERROR INTRODUCED BY WEIGHING ONE DAY IN SEVEN.

Error in a two-weeks period. In the case of short test periods with the milking machine, where the milk is weighed every seventh day, a certain amount of error is introduced. In all the two-week tests, comparing hand and machine milking, the pounds of milk were calculated by taking the average of three daily weighings and multiplying this by 14 to get the pounds of milk given by each cow for two weeks. In a short period, if the weighings were made, say, on the first and eighth days of the period and the calculations for the following weeks be based

on these, the cows would be credited with too much milk, especially where the flow of milk is decreasing, as it usually is, except for the first month or two after freshening. On the other hand, if weighings be made on the seventh and fourteenth days and the weights of milk for the preceding two weeks be calculated on the basis of these weights, the cow would likely be credited with too little milk. By taking the weights on the first, eighth, and fifteenth, and averaging these, we get probably as nearly as can be to the actual amount of milk given by a cow in a two-week period, weighing every seven days.

The following table shows the actual error in a two-week period with cows milked by hand regularly, and by cows usually milked with the machine, but which were milked by hand and weighed daily for two weeks in September, owing to a break of the motor which operates the vacuum pump of the milking machine.

Table Showing Error Introduced by Weighing Every Seven Days, as Compared with Weighing Daily in September, 1906.

Cows.		Actual yield of milk in two weeks.	Calculated yield of milk in two weeks.	Error by calculat- ing increase (+), decrease (-).
		Lbs.	Lbs.	Lbs.
106	Milked by hand regularly.	259	270.2	+ 11.2
98		221	218.4	- 2.6
122		306	306.4	+ 0.4
101		114	112	- 2.0
Totals		900	907	+ 7
69	Ordinarily milked with machine, but milked for two weeks by hand.	225	224	- 1
86		277	270	- 7
90		365	378	+ 13
78		528	518	- 10
87		386	364	- 22
102		292	308	+ 16
70		320	340	+ 20
Totals		2,393	2,402	+ 9

By following the plan indicated of averaging the weights of three daily milkings and multiplying by 14, to get the pounds of milk given in two weeks, we find that the total error introduced in the case of four cows regularly milked by hand, was 7 pounds milk.

In the case of the second group of seven cows the total error in the calculated yield of milk for the seven cows was but 9 pounds. The error

on one cow was 22 pounds too high, and on another 20.2 pounds too little. It seems probable that in a group of cows used for experimental purposes that errors will about counterbalance each other, and that the results calculated in the two-week tests are not far from the actual milk produced by the cows in a group, though the results may be considerably too high or too low for individual cows, in a short test.

Error during Four Months. Four cows in the herd were milked most of the time during July, August, September and October by hand. The cow, "Dreamy," was not purchased until about the middle of September, hence her record is available for comparison for only about six weeks. "Adelaide" was milked with the machine for about half of July, during which period her milk was weighed every seven days.

The table shows the error introduced by calculating the monthly milk yield on the basis of four or five weighings monthly. The dates selected were those used for weighing the milk from machine milked cows and multiplying by seven, three or four times and once by three, nine or ten, according to the number of days in the month. An example will illustrate: During July five weighings were made of the milk given by machine milked cows. The dates were July 2, 10, 17, 24 and 31. Cow No. 98 gave 21 pounds on July 2, and was credited with $21 \times 7 = 147$ pounds for that week; July 10, $29 \times 7 = 203$ pounds; July 17, $27 \times 7 = 189$ pounds; July 24, $25 \times 7 = 175$ pounds; July 31, $26 \times 3 = 78$ pounds, or a total of 792 pounds for the month.

During each of the other three months only four weighings were made and the weight of milk given at the fourth weighing was multiplied by 9 or 10 according to the number of days in the month.

Table Showing Error Introduced by Weekly Weighings Instead of Daily, for Four Cows Milked for Considerable Time by Hand and where each Milking was Weighed.

Month. 1906.	"Kalopathakes" (Jersey).			"Nero's Lass" (Jersey).			"Dreamy" (Jersey).			"Adelaide" (Holstein).			Average error per cow.
	Actual.	Calculated.	Error.	Actual.	Calculated.	Error.	Actual.	Calculated.	Error.	Actual.	Calculated.	Error.	
July	Lbs. 807	Lbs. 792	Lbs. —15	Lbs. 709	Lbs. 729	Lbs. +20	.....	.....	.....	Lbs. 966	Lbs. 931	Lbs. —35	Lbs. —30
August ..	655	638	—17	719	720	+ 1	.....	.....	.....	766	746	—20	—36
Sept.	464	462	— 2	627	627	.....	246	249	+ 3	541	550	+ 9	+10
October .	498	493	— 5	586	586	.....	407	410	+ 3	387	400	+13	+11
	2,424	2,385	—39	2,641	2,662	+21	653	659	+ 6	2,660	2,627	—33	—45

The foregoing results show that the total actual milk yield of the four cows during four months was 8,378 pounds. The calculated yield of milk was 8,333, making a difference between the actual and calculated of 45 pounds, or .53 per cent.—a little over one-half of one per cent. This we consider near enough for all practical purposes, and indicates that the records of the cows calculated from weekly weighings are substantially correct for weights of milk.

NOTES.

Cows No. 66, 96 and 97 (Ayrshires) were frequently changed during the year from hand to machine and from machine to hand milking. Almost invariably the change from hand to machine milking caused a decrease in the daily milk flow of from two to four pounds milk per cow, while a change from machine to hand milking seemed to cause an increase of like amounts. Two of these cows have short teats and are possibly the most difficult cows in the herd to milk by hand, hence we were specially anxious to milk them with the machine, but they did not take to it very well. They offered no resistance to the machine in the way of kicking, but they did not let their milk down well. In the case of No. 97, if the operator commenced to "manipulate the udder" the flow of milk would stop at once and the cups would immediately drop off.

On September 20th cows No. 97 and 66 gave 63 pounds milk for the day. With the machine they gave 29 pounds, and by "stripping" after the machine, 34 pounds were got from the two cows. They were put on hand milking next day. The second day after, they gave 68 pounds milk. The day after machine milking the weights of milk by hand milking were much the same as when milked by machine.

Cow No. 101, a grade Jersey, had been giving about 26 pounds milk per day during the month of June. At the first time of weighing for the next month (July 2) she had dropped to 11 pounds, without any apparent reason, except that it may have been due to more or less excitement during the excursions. She was immediately put upon hand milking. She never returned to her normal flow, but continued milking until November. During July she gave from 12 to 15 pounds milk daily. Our herdsman was confident that had she been continued on the machine she would have been dry by the end of July.

On July 10th, Nos. 106 and 107 (Holsteins) gave 23 pounds as "strippings" after milking with the machine. The total yield of milk from the two cows on that date was 57 pounds. On the 11th about half the yield was in the form of "strippings." On July 12th both these cows were put on hand milking, when the yield was increased to 65 pounds. However, this increase was in part, at least, only temporary, because on the 13th the yield had dropped to 62 pounds, and on the 15th it had dropped to 57 pounds, or the same as it had been when they were milked with the machine on July 10th. Both of these cows were more or less

advanced in lactation, which apparently was affecting the milk flow. The most marked effect in the case of these two cows appears to have been on the percentage of fat. No. 106 tested 2.7 per cent. fat for the two weeks in July when milked with the machine. During August, when hand milked, her monthly composite test was 4.2 per cent. fat, or an increase of 1.5 as compared with the previous month. No. 107 tested 4.0 per cent. for July and 4.5 per cent. fat for August. (In both cases, samples were not taken for testing during the latter part of July when milked by hand.) No. 107 continued milking to the end of September and 106 to the end of November. In both cases they would likely have dried much sooner had they been continued on the machine. However, this is a point very difficult to determine, as it is almost impossible to say that a cow would, or would not, have dried up at any particular time had conditions been other than they were.

CLEANING THE MACHINES.

One of the questions frequently asked is the following: "Are the machines difficult to keep clean?" We may answer this, "Yes" and "No." To keep the machines bacteriologically clean is somewhat difficult; to keep them ordinarily clean is not so difficult. We give the directions of the manufacturers, and if this were sufficient it would be comparatively simple to keep the machines clean. However, this is not sufficient to keep the machines *ordinarily clean*. The parts of the machine which come in contact with the milk have to be boiled at least once a week, and all the various tubes have to be thoroughly cleaned with brushes made for the purpose. To obtain sanitary milk or milk with a low bacterial content, boiling and special cleansing should be practised daily. As a rule, this means too much labor for the *average* farmer, and could be followed with profit only on special dairy farms where the milk is sold for an extra price.

The directions sent us by the manufacturers for cleaning are:—

1. "As soon as the milking has been completed, and before the milk has had a chance to dry in the cups or tubes, a supply first of cold and then afterwards hot water should be provided. The bottoms of the machines should be rinsed off with cold water. After this each machine should be placed on top of the milk pail and connected with the vacuum pipe. With the machine running at regular speed and the cocks turned off, hold both sets of teat cups in the cold water and turn on the milk cocks. The water is drawn through the teat cups, and through the rubber tubes, rinsing out all the passages through which the milk has passed. As soon as the cups and tubes are thoroughly rinsed with cold water, hot water in which sal soda has been dissolved (2 heaping tablespoonfuls to each pail of water) should be sucked through the teat cups and machines. All should then be rinsed with fresh, boiling hot water; also, last of all, the bottoms of the pulsators should be thoroughly washed with the hot water. With each milker equipment there is furnished a small brush with long wire handle; this may be used to scrub out the rubber tubes when necessary."

Note.—NEVER RUN HOT WATER through the machine and pipes until cool water has first been used. Otherwise, the milk will be cooked onto the surface of the teat cups and tubes.

"Do not use soap powders. So far as we have been able to find, sal soda is by far the best for this purpose. The object of its use is to cut the fat out from the interior surfaces of the rubber tubes. If this fat is not thoroughly removed it will injure the rubber.

"After washing the machines, draw out the piston and wipe it and the inside of the cylinder clean and dry, and occasionally wipe these parts with an oily cloth.

"Each evening just before using, it is well to suck scalding water through the cups, tubes and machine, in order to destroy any bacteria which may have lodged in them.

"Before the teat cups are applied to the cow her teats should be thoroughly cleansed with cool water during warm weather and warm water in cold weather, but they should be dried before putting on the teat cups.

"The pieces of hose that connect the pail with the stanchion cocks should be kept clean inside and out.

"During the winter, machines must be kept in a room where the temperature is always above freezing. When the machines are too cold they will not pulsate properly.

"Never leave rubber parts hanging in the sun as it injures the rubber.

"*Soaking in Brine.*—A wooden tank four feet six inches long by six inches wide and six inches deep inside should be provided in which to keep all rubber parts soaking in brine while not in use.

"The brine should be one quart of salt (regular butter salt) to ten quarts of water. The brine is very necessary to keep the tubes sweet and free from bacteria, also it is of great advantage in preserving the rubber."

"*Later Directions.*—In place of soaking the rubber parts in brine we have lately been using lime water, made by adding quick-lime to water—say, about one pound of lime to two pails of water. This seems to be very effective in keeping the rubber parts sweet and sterile, and at the same time acts as a preservative of the rubber and has an advantage over brine in that it does not corrode the metal teat cups and connectors, and we would therefore suggest its use in place of brine.

"*Barn Pipes and Drip Cocks.*—As soon as the milking is finished, both morning and evening, the drip cocks on the pipe which extends through the barn should be opened and left open until the next milking. It is well to occasionally open the stanchion cocks that are on the barn pipe and farthest from the pump, and then run the pump for half an hour or more to thoroughly dry out the pipes."

On one or two occasions we had complaints from customers regarding the flavor of the milk, but upon investigation we were satisfied that any cause for complaint did not come from the milking machine, but probably from a fly repellent which we were using on the cows to keep off flies. Nearly all such substances have a strong odor, and there is danger of tainting the milk unless used with great care.

INFLUENCE OF VISITORS DURING MILKING TIME.

The manufacturers of the milking machine are strongly of the opinion that the presence of visitors at the time of milking is very harmful. At one time we thought there was something in this point, and we excluded visitors from the Dairy barn at milking time for a considerable period during the summer. Later observations led us to believe that in the case of our herd, at least, the presence of visitors had little or no effect upon the cows, because our cows are accustomed to visitors nearly every day.

Mr. H. B. Gurler, an Illinois dairyman, has posted notices in his stable excluding visitors, believing that "the cows will not do their best with strangers in the stable." The Professor of Dairying at one of the American stations where they have milking machines similar to ours, reports on this point as follows: "Of course everyone knows it is not a good thing to have cows unduly excited at milking time, but our cows are certainly accustomed to large numbers of visitors, and it seems to us that the cows even milk better when we have had a crowd in the barn. If the fault is with large numbers of visitors, why is it that the stripper is able to get the milk from the cows after the machine?"

It is possible that cows not accustomed to the presence of strangers while being milked, would become somewhat nervous and give less milk, but where the cows are accustomed to strangers at all times, the effect is probably very slight. It is a point, however, upon which it would be difficult to obtain exact information.

DURABILITY OF THE MACHINES.

So far as we can see, there is very little in connection with the machines which is likely to get out of repair, with careful handling. The rubber mouth-pieces should be made of material which will stand boiling. We spoiled a number of ours by boiling them.

CONCLUSIONS.

1. In the comparative tests made of hand and machine milking for short periods, the results were in favor of hand milking in all tests except one.
2. When the machine was compared with *inexperienced* hand milking there was not so much difference between the results got from hand and machine milking, showing that under certain circumstances the machine might be equal to hand milking for at least a short period of time.
3. The general tendency was for the cows to go dry sooner than they were accustomed to do with hand milking. This was more particularly the case with the older cows. However, this is a point not easily solved as cows vary in this respect, from year to year.

4. Some of our young cows have given very good results with the machine, indicating that it may be possible to breed and train cows which will give fairly good results under this system of milking, though they are not likely to be so good as if trained to hand milking.

5. Special care needs to be exercised in the cleaning of the machine, otherwise the milk is liable to be tainted. Simply sucking water through the parts is not sufficient. All parts of the machine that come in contact with the milk must be thoroughly scalded or steamed, at least once a week, and for good results this should be done daily.

6. On average farms, where ten to twenty-five cows are kept, we do not believe that it would pay to install a milking machine at present. On farms where fifty to one hundred or more cows are kept, and where labor is very expensive, and difficult to get, and where the owner of the cows is not so particular about maximum yields from individual cows, the milking machine is worthy of careful consideration. However, we do not consider the machines at present on the market as anywhere near perfection, and we look for great improvement in them during the next few years.

BACTERIA AND THE BURRELL-LAWRENCE-KENNEDY MILKING MACHINE.

BY S. F. EDWARDS, PROFESSOR OF BACTERIOLOGY.

Our investigation with the Burrell-Lawrence-Kennedy milker was of brief duration. The object was only to determine whether pure milk could be obtained with the machine milker under conditions that would make its use practicable upon the farm.

No attempt was made to determine the species present in the samples beyond the detection of acid producers and those which liquefy gelatin. Milk produced under even more cleanly conditions than usual, either by machine or hand milking, will contain a varying number of species of bacteria. Of these, the acid-producing organisms are largely lactic acid bacteria, which only sour the milk and are harmless. Organisms which can liquefy gelatin can cause a chemical disintegration of the nitrogenous constituents of the milk, visible to the eye in old milk, as a liquefaction of the curd. During this process products may be formed which are poisonous to the body, causing gastro-intestinal disturbances. Aside from the acid producers and liquefiers, other species may be present, some inert, while some, alone or in associative action with others, are apt to produce objectionable odors or flavors in milk, or its products, butter and cheese. Disease-producing organisms may be present if the animal is diseased.

As bacteria are always associated with dirt and filth, the bacterial flora of milk, either machine or hand drawn, will depend upon the cleanliness of the surroundings where the milk is secured. In this connection it may be said that the conditions existing in the College dairy barn are far better than those which prevail upon most farms.

The Cleanliness of the Milking Machine. From the time the milker was installed until after the test began, a period of about seven months, the machine was cleaned according to the directions issued by the manufacturers. The first samples were taken as the milker was ordinarily operated, the cows being milked by machine and by hand on alternate days. The results are shown in Table I.

As seen by a glance at the table, every sample of machine-drawn milk showed a very high bacterial content, while most of the hand-drawn samples showed a bacterial content comparatively low. In the production of "sanitary" or "certified" milk in cities, the standard established by

different health authorities varies from 10,000 to 50,000 bacteria per c.cm. In every case but one the hand-drawn milk was as pure as "certified" milk, while in all the machine-drawn samples the limit was far exceeded.

Table I. *Bacteria per c.cm. (about 20 drops) in Machine-drawn Milk and Hand-drawn Milk.*

Date.	Milking.	Cow.	Total bacteria.	Acid producing.	Liquefying.
July 23.....	Machine....	*78 and 90..	216,000	22,200	26,700
" 25.....	Hand	" " " ..	8,400	400	3,100
" 26.....	Machine....	" " " ..	712,000	26,700	17,700
" 27.....	Machine....	" " " ..	267,300	40,000	45,000
" 30.....	Hand	" " " ..	68,900	65,600	1,200
August 3.....	Machine....	" " " ..	574,000	102,000	24,600
July 31.....	Machine....	96	322,000	25,000	1,500
August 3.....	Machine....	"	203,000	41,000	3,500
" 7.....	Hand	"	20,000	4,000	6,000
July 26.....	Hand	107	17,200	1,200	4,400
" 27.....	Machine....	"	1,208,000	39,600	31,400
" 30.....	Hand	"	23,800	21,700	400
" 31.....	Hand	"	3,200	400	300

* Mixed milk of two cows.

In the next series of samples, the aim was to determine the effect of boiling the rubber parts and cover of the milker once a week. The results are shown in Table II.

Table II. *The Effect upon the Bacterial Content of Machine-drawn Milk, of Boiling the Milker Once a Week. Bacteria per c.cm.*

Date.	Cow.	Total bacteria.	Acid producing.	Liquefying.	Remarks.
August 10..	*78 and 90..	7,000	.....	6,000	Parts boiled 3 minutes.
" 10..	96.....	16,335	600	8,000	" " 3 "
" 17..	*78 and 90	96,000	.....	18,800	" " 3 "
" 17..	96.....	68,000	2,800	4,400	" " 3 "
" 23..	*78 and 90..	155,500	17,500	52,000	Parts not boiled since August 17th.
" 23..	96.....	141,500	8,500	16,000	Parts not boiled since August 17th.
" 24..	*78 and 90.	47,000	15,500	7,500	Parts boiled 2 minutes.
" 24..	96.....	15,800	6,000	4,000	" " 2 "
October 12..	*78 and 90..	15,600	.....	4,550	" " 2 "

* Mixed milk of two cows.

A comparison of the bacterial content of the samples taken at the first milking after the parts of the machine were boiled with that of the samples taken when a week had elapsed after the parts were boiled, shows the futility of attempting to produce pure milk by relying upon a thorough cleaning of the milker only once a week.

An expert representing the manufacturers prepared the milker for the next samples, spending considerable time and care in getting every part of the machine thoroughly washed, boiled, and steamed. Only one cow was milked for each sample, and only the total number of bacteria present was determined. The sample from cow No. 90 showed 1,407 bacteria per c.cm., and from cow No. 78, 1,776 bacteria per c.cm. These results show that it is possible to secure milk having a very low bacterial content with the machine milker, but the time and care required to prepare the milker for producing such milk would make it impracticable for any but the large dairy farmer.

Wholesome milk can be secured and bacteria largely excluded by observing a few precautions to prevent bacterial contaminations. The source of these contaminations may be stated briefly as follows:—

The Stable. Manure teems with different kinds of micro-organisms, and if allowed to accumulate in the stable a part of it becomes dried, the bacteria contained are thrown into the air by movements of the animals and caretakers, and many of them settle into the pails during the milking. Straw and other litter used for bedding contribute a large number of bacteria to the air when stirred, as also does feed of any kind which makes dust in the stable. Bedding and feeding, therefore, should be done at least an hour before milking, or after milking. In short, the stable should be as free from dust as possible during milking, either by hand or machine.

The Animal. As hairs and particles of dirt from the animals carry many bacteria, the cows should be kept groomed, and the flanks and udder should be wiped with a damp cloth just before milking. This will keep much filth out of the pails. A few drops of milk remain in the teats after milking, and bacteria present or gaining access from around the opening of the teat may multiply here to many hundreds from one milking to another. If in milking the first few strippings are rejected, these bacteria will be eliminated.

The Milker. The milker should wear clean clothes, have clean hands, and should be a healthy individual. Many cases of typhoid fever and diphtheria have resulted from drinking milk handled by convalescents from these two diseases.

Utensils. All utensils should be first rinsed thoroughly in cool water, washed in hot water containing a little sal-soda, thoroughly scalded or boiled, and kept inverted until ready for use to prevent bacteria falling into them from the air.

All these precautions are equally important in producing pure milk, whether machine or hand milking is practised, and only by their observance can the farmer or dairyman produce pure milk. It remains, then, for each individual, who alone is the best judge of his own conditions, to determine whether he would be warranted in making the outlay of money necessary for the instalment of a machine milker.

SUMMARY.

1. It is possible and practicable for the general farmer as well as the dairy farmer to produce pure milk, either by hand or machine milking.

2. To produce pure milk, by hand or machine milking, scrupulous cleanliness must be maintained about the stable and animals, the person of the milker, and the utensils.

3. Strict sanitary precautions being observed, hand-drawn and machine-drawn milk in our test showed approximately the same average bacterial content.

4. The mere fact that milk is drawn by the Burrell-Lawrence-Kennedy milker is by no means a guarantee of its purity. It may contain many more bacteria than hand-drawn milk under similar conditions.

5. We would not advise the installation of a machine milker, unless the farmer or dairyman is prepared to fulfil the sanitary conditions essential to the production of pure milk.

Ontario Department of Agriculture.

WOMEN'S INSTITUTES.

The Production, Care, and Uses of Milk.

PURE MILK SUPPLY.

Milk is the raw material used in one of our most important agricultural industries, and it is an article of daily use in the dietary of nearly every man, woman, and child. There is no more vital question before those who produce milk for commercial purposes, or who use it from day to day as an article of food, than its production under sanitary conditions.

The "Women's Institutes" of the Province is one of the most forceful organizations that we have, and the information presented in this bulletin is brought to their notice in the hope that they will use their influence to the betterment of the milk supply, not only for consuming in its natural state, but for manufacturing into butter and cheese.

The ladies living in the towns should see to it that the milk used by them is produced under sanitary conditions, properly cooled as soon as drawn from the cow, and handled in a cleanly manner from that time until it reaches them.

The women in the country do not perform much of the actual work of milking the cows and cooling the milk. They usually, however, have this work more or less under their supervision, and, if they so desire, can do much to improve the general conditions surrounding the production of milk, by insisting that those who milk the cows are properly dressed and wash their hands before they begin milking. By insisting upon cleanly methods and proper cooling of the milk they can do much to increase the quality of the raw material. Care in this respect not only insures a better quality of cheese and butter, but a larger *quantity*.

We wish to commend to the *careful reading* of the Institute members the statements made by the Deputy Minister of Agriculture, as to the part which the women of the farm can take in bettering the conditions surrounding the cheese and butter industry. More or less repetition will be found in the material presented in this bulletin, but the importance of the subject, and the different viewpoints from which it is considered, are a justification for printing the papers and addresses as prepared by the persons named at the head of the different sections.

GEO. A. PUTNAM,
Superintendent.

WHAT THE WOMEN'S INSTITUTE MEMBERS CAN DO TO ENSURE A PURE MILK SUPPLY.

C. C. James, Deputy Minister of Agriculture for Ontario, in an address before the Dairymen's Convention, held at London in January last, placed special emphasis upon the necessity for pure milk, and in the course of his remarks referred in most hopeful terms to the possibility of furthering the interests of the campaign for a pure milk supply through the Women's Institutes. A portion of his remarks are given below :—

“Let me tell you that the first genuine ray of hope I have seen in connection with this work came into this question, so far as I am concerned, in the month of December, when I saw gathered at the Agricultural College, 400 or 500 women from the farms of the Province of Ontario. It was the most inspiring convention I ever saw, and the most interesting audience I ever addressed. Just picture to yourself a room like this packed to the doors with women from the farms of our Province, and every woman with her pencil and note-book, taking notes of what was going on. I said to myself as I sat there and looked at them, ‘We are at last getting a grip such as we never had before on the agricultural community of this country.’ When five hundred women from all parts of Ontario will come from the farm homes to a convention of that kind, meaning business, and to take up questions of vital importance to the agriculturists of this country, there is hope that we are at last going to do something, and that we are going to begin at the right source. The women of this country can do what the men cannot do, and they will make the men of this country do what they would not otherwise do. If the farmers’ wives and daughters tell the farmers that they have got to put their stables in a clean condition; that they have to carry on their work in a clean way; that they have to keep their utensils in a clean manner and send the milk to the cheese factory in a clean state; take my word for it, it will be done. We have at last got our foot into the farmers’ home, and until you can revolutionize the farm home life of this country there is not much hope of permanent success. It is all very well for the farmers to leave home and come to London or Ottawa for a few days’ or a week’s holiday, have a pretty good time listening to the speeches, and then go back again and perhaps not be able to tell very much of what went on, except that they heard some good songs, and had a good time. But that is not what is going to revolutionize this country. You have to send men home with the determination that they are going to clean up and do things better than they ever did before. The centre of the farm work of this country is not on the front concession or on the back road; it is not out in the stable or in the fields, but it is right in the home where the farmer lives; and if we can only start within the four walls of that home we will accomplish a great deal more than we have been able to do through conventions or dairy schools, or anything else. If we can deliver the gospel of cleanliness in the farm homes of this country there is hope of doing something.

When I saw that Women's Institute convention listening to addresses on the subject of pure milk production, and of what it meant to the health, wealth and happiness of the country, I said, 'This is the best dairy convention I have ever attended, and this is the best work we have ever undertaken in this Province.' The Farmers' Institute work grows very well, but the Women's Institutes of this country are growing at a tremendous pace. You have no idea of the great social revolution that is taking place in connection with the agricultural life of this country. I pleaded with these women to go home and demand that something should be done in the rural public schools of this country to help out our agricultural work. If we can get the farmers' wives and daughters to work on this question of pure milk, whether for home consumption or cheese-making and butter-making, and if at the same time we can have introduced into our rural schools some simple instruction so that the boys and girls will get some little knowledge of what milk is, of what the value of milk as a food is, and the necessity for its being kept absolutely clean, then, and not till then, will we have this question finally started along right lines. Otherwise we will meet year after year in convention and go over the same old ground again, meet the same old difficulties, and will not make half the progress that we should have made."

MILK AS A FOOD.

By Mrs. Lillian Gray Price, Toronto.

It is interesting and beneficial to have a knowledge of the care and handling of milk in regard to cleanliness of the cow, milk pails, and vessels and of the milk itself, all of which cannot be given too much attention; for such attention is absolutely necessary; but the subject seems incomplete without a study of milk in regard to its place among the food-stuffs that we are constantly using to build up bodily strength to fit us for the work of living.

When we have taken the milk from the cow and carefully and properly attended to it until we have it placed away ready for use by the family, our knowledge, and indeed our desire for knowledge, should not stop there, but we should think further and deeper, and endeavor always to know just what this most important food supplies in the great economy of bodily strength and vigor.

In order to understand the food value of milk, or in fact of any food, we must have a definite knowledge of the composition of the body, and of the classes of foods necessary to support life. Briefly, we require to continually replace in the body, muscle and tissue, fat, mineral matter, heat and energy and water. We know that with every movement we make and with every thought we think, bodily material is being used up and therefore being worn out; and in order that we may not entirely wear out and die, we must replace this loss as it occurs. This we do precisely as we keep a fire going, by adding fuel from time to time as the demand is created, our fuel being food.

For each different substance in the body we have corresponding food materials. To build up muscle and tissue we use muscle and tissue-building foods, or proteids, such as meat and eggs, two very common examples. For our fat we eat butter, cream, olive oil, etc. We get mineral matter in small quantities in all our ordinary foods. Salt is perhaps the best known example of a mineral food. Heat and energy is supplied by our carbohydrates or starches and sugars in any form. Water we find in all foods. Should any food contain the proper proportion of all five classes we call it a "perfect food," hence eggs and milk come under this heading. Thus we see the relationship between the composition of the body and of the foods. No true food contains any other thing than one or more of these elements or compounds, and to make our eating not merely a matter of hunger and taste, we should bring our knowledge to bear upon it and make it a matter of thought and science.

Milk, then, contains the five different elements necessary to support life. If we allow milk to stand for some time we can skim off the cream, which is the fat. Then add a little rennet and the milk curdles, and forms curds and whey. The curd is the muscle and tissue-building part or the protein; the whey is composed of water, a little mineral matter, and the heat and energy part in the form of milk sugar. In composition 100 pounds of average milk contains about 87 pounds of water, 4 pounds fat, 5 pounds milk sugar, 3.3 pounds protein, and 0.7 pounds of mineral matter or salts.

In regard to its nutritive value, milk stands very high, and its worth is not appreciated as it should be, especially when we compare its cost with its value as a food. We have said that milk is a perfect food in itself, and it is, with slight modifications, for an infant; but, for an adult, the different materials are not in the proper proportions to continuously nourish the body alone, and so require to be used with other foods to round out the diet and make a balanced ration. A lunch of milk alone would nourish the body a good deal, but a lunch of say 10 ounces of bread and a pint of milk would be more nourishing and satisfying, and will equal in nutritive value a lunch of soup, meat, potatoes, bread, butter and coffee. It will not fill up the same and lead us to believe that we have been well satisfied, but we must get over this old-fashioned idea that because we have a feeling of fulness we have been well nourished. The filling up process is not always by any means the nourishing process.

The value of skim-milk is not appreciated as it should be. It still contains nearly 10 per cent. of nutritive ingredients, that is, it has nearly all the protein of the whole milk for building muscle and tissue, and making blood and bone, and half the value for giving heat. For this reason a good cook may use skim-milk to advantage in preparing the daily meals, thereby giving good food to the family at half the cost of whole milk.

Then, too, we have buttermilk, which is also valuable. One glass of good buttermilk is equal in food value to half a pint of oysters, and yet what a difference in cost. In composition it is similar to skim-milk, but has slightly less protein and sugar, and a little more fat.

In summarizing, then, it is seen that whole milk, skim-milk, and buttermilk are all muscle and tissue-building foods, though not as much so as meats. They are all useful as sources of energy, and it is only on account of the large proportion of water that skim-milk cannot be used much more than it is. But let us remember that both whole milk and skim-milk are *cheap* foods, and should be used more, especially for small children and growing boys and girls.

Milk is classed among the very digestible foods, although there are some to whom it is very indigestible, but this is a peculiarity of that individual stomach. When it is taken into the stomach it is quickly curdled by the acid of the digestive juices, and in this regard it should be remembered that to be digestible, milk should be sipped or taken slowly, so that it may enter the stomach and curdle in a soft, flocculent mass instead of in hard lumps, as would be the case if taken too quickly. This is one reason why it is well to use milk with other foods, and not take it in large quantities alone. Limewater is frequently used in milk to prevent too rapid coagulation, in cases of weak digestion. Milk when boiled is rendered indigestible because the proteid or muscle and tissue-building part is hardened, and thus made difficult for the stomach to work upon. This shows us that milk when cooked should never be boiled if possible to prevent it. Again, in heating milk it is always well to cover it. If left without a cover a scum forms on the top and it has to be removed to make the milk palatable, and thereby we lose the most valuable part of it, the protein.

Milk is a product which we are handling daily, and using continuously, and it is one of the most encouraging signs of progression in our women's work to see this study being given prominence. To further increase our knowledge of the proper care and handling of milk, and its use as a food, is to materially assist us to higher planes of living.

MILK—ITS PRODUCTION.

(An Address by Prof. H. H. Dean, before Ontario Women's Institute Convention, held at Guelph, December, 1906.)

The subject assigned to me is "Milk," more particularly the "Production of Milk."

Atwood, an American authority, says that one quart of milk has about as much nutritive value as a pound of beef. Now, we can purchase in milk nutritive material at about one-third the cost that you can get it in beef. I would like you to bear in mind that milk is one of the cheapest of the nutritive foods which we may purchase, and has this great advantage over beef, that it is almost entirely, if not entirely, digested. Man, in the process of the study of this question, looked for some animal which could give him this nutritive material at the smallest cost, and after experimenting with all the lower animals, he came to the conclusion that the cow was the one which would produce milk in the greatest quantity and at the lowest cost. Among the lower animals, the

cow is undoubtedly one of the greatest benefactors of the human race. She contributes more to his health and happiness than any other animal.

Those of us who have read "Middlemarch" will remember that the author makes one of the characters give this statement: "It would be interesting if we could know what the cat thinks of us." Since reading that, I thought it would be very interesting if we could know what the cow thinks about us.

One morning I heard an unusual commotion among our cows. Usually they are very quiet, but this morning I noticed quite a stir in the stable. I listened and heard the word "Man." Now this is such an unusual subject among the gentler sex, that I thought I would listen to what was being said. The mild-eyed Jersey was the first speaker. She said, "Men are such unfeeling and inconsiderate creatures. There were some farmers in here the other day, and they made some very unkind remarks regarding my hook-bones." The next speaker was the alert Ayrshire. "You know," she said, "I had a funny experience last summer. A number of us were playing in a field. We were talking quite loudly—men call it bawling—and jumping about, and a man came over and said that he would like to umpire the game." The Holstein said, "Man, what is he? The most helpless creature that ever came into the world. He does not know enough to feed himself, and has to depend upon us for food."

It is undoubtedly true, that, while we consider ourselves above the lower animals, it would be very interesting indeed if we could know something of what they think about us.

The first thing I want to emphasize in the production of milk is that we must have a good cow. What is a good cow? One that will produce at least 6,000 pounds of milk, or make not less than 250 pounds of butter in one year, at a cost of not more than \$30 for feed. Such a cow as that is a profitable animal. Will you bear in mind that a careful estimate, based upon results of the cow-testing associations, states that the average production of the cows of the Provinces of Ontario and Quebec, which comprises the best dairying districts in Canada, is only 3,000 pounds of milk in the year. Is there any wonder that in some dairying districts there is not enough milk to drink. There is no money in keeping cows like this, and it is no wonder that people are not satisfied. We have in our stable a Holstein which has produced 2,522 pounds of milk in thirty days, within 500 pounds of the average annual production of cows of Ontario and Quebec. In seven days she gave us 643 pounds, and in one day 96 pounds of milk. If we had cows like that there would be no trouble about having plenty of milk to drink. A man cannot afford to keep cows that produce only 3,000 pounds of milk in a year.

One of the factors that we must bear in mind regarding a good cow is that we must have a strong, healthy, vigorous one, if we would have milk that has what is called vitality. I think it would be impossible to get the best milk for drinking purposes from a cow that is low in vitality.

Second, the cow must be fed the right kind of food. There are some men so generous that they will feed their cows straw all winter, give

them all the straw they can eat, and then swear at them because they will not give more milk.

It is little wonder that many farmers are unable to obtain satisfactory milk production. They do not feed. If you ask a cow what she would rather have to eat, she would answer, "Give me juicy, succulent grass, and I will give you plenty of milk." For five or six months of the year the farmer must substitute for grass such food as mangels, carrots, and corn silage. Turnips should not be fed to cows producing milk. Some people enjoy the flavor of turnips in milk, but the majority do not. If you want the best quality of milk, do not feed turnips. We should recommend the following ration for winter milk production: 8 to 10 pounds clover hay, 30 to 40 pounds corn silage, 20 to 30 pounds mangels, 8 to 10 pounds meal made up of equal parts of oats and bran by weight and 1 to 2 pounds of oil-cake, gluten meal, or pea meal. The ration to be given in two feeds daily to each cow. A cow does not need to be fed more than twice a day under ordinary conditions.

Give the cow plenty of water. How much water do you think was drunk by the cow that gave 96 pounds of milk in one day? Nearly 200 pounds. That does not mean that the milk was water, as her milk tested about 3.5 per cent. fat. You cannot water milk through the cow. Only man has learned that trick.

Next, give the cow plenty of salt. Treat her kindly. Treat her as if she were your friend. Any man who will kick a cow or strike her with a pitch-fork should be taken by the back of the neck and kicked out of doors.

The cow house should be kept clean and sweet and well ventilated. It is impossible to get good milk from a cow kept in a stable that is not clean. I would like you to see the stable in connection with our College, and I think you would agree with me that the air of that stable is probably as pure as it is in this room. Such a condition can be got at small expense. Bulletin 143 gives instruction as to how to ventilate a cow stable at small cost. No man should keep his cows in a small, damp, filthy house and expect good milk fit for human use. The cows must be kept clean. If you suggest currying the cows, farmers will laugh at you, but nevertheless, cows need to be regularly brushed and curried. They need to be kept clean as much as horses, if not more so. It is impossible to get clean milk from dirty cows. You have only to notice the sediment in a milk bottle to know that this is a fact. The people of this country should rise and demand clean, sweet milk.

Next, cows should be milked in a kindly manner. The person doing the milking should have on clean clothes. Men do the milking, as a rule. Women should not be asked to go to the barn to milk cows, and especially not through a dirty barnyard, into a dirty barn, to milk dirty cows. As a rule, the milking should be done by a man. He should have on clean clothes, and should wash his hands before milking. The average man will think nothing of sitting down to milk with dirty hands. Milk in a quick manner into a clean pail. The milk, immediately after it is

drawn from the cow, should be strained, and cooled to a temperature of 50 or 60 degrees.

If you get milk cooled to 50 or 60 degrees, it can be kept for a long time, and will be fit for human consumption. Milk which is not cooled at once forms a medium for the development of bacteria, and very often contagious diseases are spread through an impure milk supply. Milk which is sold to towns and cities ought to be under the strict control of the municipality, and the people of the municipality should see to it that the milk is above reproach. In Glasgow and Copenhagen the milk is inspected, and the people of those cities get milk of a much higher standard than is sold in this country, and at no greater cost.

I see no reason why skim-milk should not be sold. It is of special value to growing children. A great many cities have by-laws prohibiting the sale of skim-milk. I hold that skim-milk should be sold, that the poor of our towns and cities ought to have it. But it is hard to get anyone to buy skim-milk, because it gives one the appearance of being poor. Buttermilk is a most healthful drink. If people would drink buttermilk instead of whiskey, it would probably be better for all concerned. Scientists tell us that there are germs in sour milk which fight against the germs causing death to the human body. It is also said that buttermilk has a tendency to lengthen life. People in some parts of Europe drink largely of sour milk, and these people live to a very great old age.

We look to the women of this country to start a campaign for the production of clean, sweet milk that will build up a nation of strong girls and boys. We find our Governments spending large sums of money to bring people into Canada. What are they spending for the promotion of the health of the boys of this country, especially when small? Any one boy of this country is worth a dozen from any other country in the world. Make the conditions such that girls and boys may build a strong and vigorous nation. I look to the women of this convention to start a campaign in favor of pure milk.

CARE AND HANDLING OF MILK.

(Address by Miss L. Shuttleworth, Guelph, at the W. I. Convention, December, 1906.)

Dairying, as it is to-day, may be considered the leading industry of our country, and justly so. There is not a meal in the average family that does not in some form, or to some extent, depend upon milk to furnish a part of the general variety used. Nothing seems so equally wholesome to both old and young, even to the greatest extremes, as the product from the cow. An article of diet so generally used as milk necessarily demands the greatest care possible in its production and handling.

The public is beginning to question whether the people who furnish milk and its products have not been either careless or indifferent as to the care of their surroundings. Therefore, the question of cleanliness, from the producer's standpoint, is not a matter of sentiment, but a prac-

tical business proposition. The man who knows that the milk he is using or drinking is produced in absolutely clean and sanitary surroundings, has a keener appetite for the same. The man who eats butter is much more likely to want a second helping if he knows that the butter has been produced by cleanly methods from clean and sanitary milk. So with cheese and all milk products.

Farmers who supply milk for butter or cheese making should take as much care of the milk as those who produce milk for bottling purposes. A thing that is worth doing at all is worth doing well, and one of the things a dairyman must learn is absolute cleanliness, a cleanliness different from what they have ever considered before. The first thing to be borne in mind is that milk is naturally a pure product. If any milk is found unclean, unwholesome, or disproportioned in its component parts, the chances are it is not the fault of the cow. In all such cases the presumption is that some person is to blame, either the one who cares for the cow or the one who handles the milk. Milk containing a large amount of sediment is suspicious. Particles of dirt are a sign that germs are abundant. This unclean milk may be dangerous as well as disgusting. What would you think of finding a teaspoonful of sediment at the bottom of one quart of milk? And yet I have seen it. We consume more filth in our milk than in any other article of food.

The secret of milk preservation lies in these two rules: First, cleanliness; second, keep at a low temperature; and it must be classed as a piece of good fortune that a food product of such value and widespread use can be maintained by the observance of so few and so simple precautions.

In the handling of milk from the cow to consumer, use as few vessels as possible, the fewer the better. We want clean cows, clean milkers with clean hands, clean and well ventilated stables, clean strainers, pails, and separators. It is well to form the habit of milking quickly and cooling quickly.

We cannot have milk that is right, and do the milking in a stable that is full of floating life. Now, what is the cause of all our trouble? The first thing that impresses one as very objectionable is the dirty condition of the cows. I sometimes wonder why it is that the horses are so well cared for while the faithful dairy cow hardly knows the touch of a brush. The plain fact is that more or less dirt and unseen millions of bacteria fall into the milk pail. Those who use separators and see all the impurities which come out of the milk, have a fair idea of how much this amounts to, and I may say that it is a good deal more than it should be in an article of food.

To determine definitely the amount of filth that gets into milk during the process of milking, and how much this can be lessened by washing the udders, the following comparison was made. It was determined after several trials with three different milkers, that it requires an average of $4\frac{1}{2}$ minutes to milk a cow. A glazed dish 11 inches in diameter, the size of an ordinary milk pail was placed in the top of a pail and held

under a cow's udder in the same position as when milking. For $4\frac{1}{2}$ minutes the milker went through motions similar to those made in milking, but without drawing any milk. The amount of dirt and dust which fell into the dish during the operation was, of course, about the same as would have fallen into the milk during the milking process. The dirt caught in the dish was then brushed into a small glass weighing tube, the udder washed, and the process continued. The dirt which fell from the washed udder was also carefully brushed into a weighing tube. After drying 24 hours the contents were weighed on a chemical balance. Many trials were made at different seasons of the year. With udders that were apparently clean it was found that an average of $3\frac{1}{2}$ times as much dirt fell from the unwashed udders as from the same udders after they were washed. With soiled udders the average was 22, and with muddy udders the average was 90 times as much dirt from the unwashed udders as from the same udders after washing. If we were to place a pail of water just beside the pail in which a cow is milked and observe the amount of sediment that has gone to the bottom and the particles of dust to be seen floating on top, it is not likely that we would be willing to pour that water into the tea-kettle to make the coffee for breakfast. And yet we use some of that cream and milk in our coffee without question. There is so much in custom. If I could not find time to groom the cows, and was opposed to washing the udders, then I would try covering with a large piece of cotton that part of her body directly over the milking pail. Tie it across her back with strong pieces of tape so that one piece of cotton would fit any of the cows. It would not take much longer to put on than for the dairy maid to tie on her nice clean apron.

Now, just a word about taint or off-flavor in the milk. As long as it is not sour it is generally received at the creameries, as the butter-maker is afraid of sending home milk which is not sour; and I know that patrons think an injustice is done them if their milk is rejected at the creamery for other reasons than sourness. But this is where they are mistaken, as tainted milk is just as bad and often more harmful to the quality of the butter than clean sour milk. I have often detected, when the lids of the cans are lifted, a strong odor of fried bacon. This is proof that the cans of milk have been kept in the kitchen uncovered. Sometimes the milk is tainted with tobacco smoke.

I am not going to criticize pasteurization or sterilization, but I do know that they are a means of covering up a multitude of sins. I do not deny that in the average milk there is plenty of bacterial life that one can destroy by heat. I think that it is a great deal better to produce the milk in such a way that it does not need the application of heat, and it is thoroughly practical to do so.

One of the essentials in keeping dairy utensils clean is to have a smooth surface. This fact should be kept in mind when purchasing, and if all seams are not flushed smooth with solder this should be done. As soon as the tin is worn off on the inside, exposing the metal, the utensils should be discarded, for they cannot be properly cleaned when in this

condition. All utensils should be washed as soon as possible after using, since the longer the milk remains on them the harder they will be to clean. They should first be rinsed with luke-warm water to remove the milk, then washed with hot water in which a little washing soda has been dissolved, using a fibre brush in place of a cloth, rinsed with hot water and scalded with boiling water or steam. Cans should never be tightly closed when not in use, and should be placed on a rack in an inverted position so that the dust cannot blow into them. If possible they should be placed where the sun can shine on them, as this will do much towards keeping them pure and sweet. Bright sunshine is one of the best known disinfectants, and has the advantage of being cheap.

I favor using plenty of white cheese-cloth in dairy work. It is especially useful to tie over the cans while the milk is being cooled. It will catch dust and many particles that might fall into the milk. It makes an excellent strainer, and yet I hesitate to recommend the use of it, knowing the careless manner in which it is sometimes cleaned. To plunge a milky piece of cheese-cloth into boiling water will ruin it forever as a strainer. The curd part of the milk is hardened on the cloth, and boiling will not remove it. In a day or two it becomes impure. To strain milk through that would taint a whole milking.

With the cow clean at milking time, the stable clean, the milker clean and clean pails, strainers and other utensils, the problem of keeping and delivering sweet milk and cream is well in hand. What most of us need is more dairy knowledge and a better application of what we already know.

The story of the cow has never grown dim among those who have known her longest, and have been the most ardent in bestowing praise on the gentle mild-eyed queen.

"Give to the lordly steed his equine grace,
Give to the farmer large reward for toil;
Render to the milkman all honor due his place,
But bear in mind the cow is mistress of the soil."

MILK—FROM A DOCTOR'S POINT OF VIEW.

(Address by Dr. Helen MacMurchy, Toronto, at Women's Institute
Convention, December, 1906.)

This is a great occasion, and I am proud to take part in such a discussion as this. I congratulate Prof. Dean on being the first person in Canada to appeal to the women of the country on the milk question. I have endeavored for a good many years to interest those to whom I had access, but I have for a long time been confident that, unless we could appeal to some such audience as this, our efforts would be in vain. But I believe Prof. Dean has succeeded in doing so this morning.

The first thing I want to say is this: It is not often in listening to a discussion that one agrees with every word that is spoken, but I want to say that I heartily agree with every statement made by Prof. Dean and

Miss Shuttleworth. In making my address, I want to be understood as corroborating all that has been said about cleanliness. If they had not said it, I would have had to say it from a medical point of view.

What we need is a new point of view on the milk question. In order to make clear what I mean, I will ask you to go back to the days when you were little girls, and your mothers allowed you the great privilege of going into the kitchen and helping to make cake or bread. How fascinating it was! You will remember how particular she was; the bake-board must be scrubbed to a snowy whiteness; then mother's hands and arms must be washed, though they were clean before; a clean apron must be put on; then when the dough was moulded into loaves and put into the pans to rise, they were covered with a clean towel and a clean blanket. And why? Because the bread was going straight from those fingers, that bake-board, towel, and blanket to the mouths of the family.

Now, that is the point of view that we ought to have about milk. Why should we be content to allow the milk to come from a dirty stable, a dirty cow, a milker's dirty hands, a dirty bottle, to the baby's mouth? Babies have been poisoned wholesale by dirty milk. I do not say in Ontario, for we have not yet sufficient information in the matter, but I do say that this has been the case elsewhere, as I can prove to you, and the probability is that it is so in Ontario also. Dirty milk means milk with too many germs in it. Now, as you know, some germs are not harmful, but when we have too many germs in milk they are harmful, and, not only harmful, but poisonous. Strychnine would not be more deadly to an infant than milk containing millions of germs in a few drops. This is what I want to say about the viewpoint. We should be at least as careful of our milk as we are of our cooking processes in the kitchen.

Not only do we need a new viewpoint, but we need to have more interest taken in the milk question. During the pure milk campaign in Boston, a talented lady, a writer of more than local fame, called on a distinguished hygienist seeking information on pure foods. She professed a lively interest in this subject, and the hygienist responded with great enthusiasm. He said that milk surpasses all other food stuffs in its potency for good or evil, that a considerable part of the current sickness and mortality of Boston is due to bad milk, and that a great many lives, particularly of infants, would be saved if intelligent people, women especially, would inform themselves fully and would exert their influence to improve the milk supply of Boston. The lady's enthusiasm for pure food did not survive this brief discourse on milk. She said: "I don't drink milk, and I am not interested in babies. Tell me what you know about lemon extract."

We should take more interest in the milk industry than we do. It is one of the most important industries of the Province, and Ontario is going to be the great dairying Province.

Now, you will not think I am too extreme, or that I am saying what is not so about babies and milk, when I tell you the following incident. A woman recently complained to Dr. Osler that Providence had taken her

child. Dr. Osler interrupted with, "Providence had nothing to do with it; it was dirty milk."

One day about the year 1900, Dr. Park, of the Board of Health, in charge of the Bacteriological Laboratory, in New York, noticed that a number of kittens about the laboratory had died rather suddenly. There is a cause for every death, and it is the business of the physician to find out why people die. What killed the kittens? Was it the milk? Prof. Dean has already told us that milk must be chilled in order to prevent germs multiplying and the number of germs in milk will vary according to the condition of the stable, the cow, the utensils and the clothes and hands of the milker. If these are clean, there will be a less number of germs in the milk. We doctors are not too particular. We do not ask that there should be no germs, but there must be a limit. We count the number of germs in twenty drops of milk, and most doctors will agree that 50,000 germs in half a teaspoonful, or twenty drops, is pretty good milk. It is good milk. In the city of Rochester they do not allow milk to contain more than 100,000 germs in half a teaspoonful in summer; or 50,000 in winter. Dr. Park found on examining the milk from which the kittens drank that it contained 70,000,000 germs, and more, in half a teaspoonful!

Now, if I were put into one word how we doctors feel about milk, I would say that we are anxious, apprehensive about the milk supply, and we cannot get people to take enough interest in it.

I will tell you about an incident which happened in the city of Toronto some three or four years ago. Dr. Sheard traced some cases of typhoid back to the milk supply. In this case the trouble came from the well-water which was used to rinse the milk cans. The next year the same thing occurred, and was traced to the same well. This ended that farmer's career as a milkman. These things are happening in our midst.

I will give you one more instance. The Assistant State Veterinary Surgeon, Dr. S. H. Johnston, of Carroll, Iowa, says that a cow was reported to him as having a bad cough, but apparently healthy otherwise. He advised the owner to have her tested for tuberculosis, but the owner did not hurry, and eight weeks after his attention was again called to her. The cow was worse, and the owner was again advised to have the cow tested. The test was made, and the cow was found to have tuberculosis. Dr. Johnston then enquired about the milk, and found that it had been supplied to three families. He found that six persons in these three families had suffered from tuberculosis and recently three had died. Only one of those cases could be traced to any other source of infection than the milk.

Every dairy ought to be under strict and thorough inspection. If people do not ask for clean milk, why should the farmer give it, if we are satisfied to pay for dirty milk? If you want clean milk, ask for it and see that you get it.

We must take some trouble about this. Dr. Kiefer, the Medical Health Officer of Detroit, says that as soon as a case of transmissible

disease is reported to their department they put down the name of the milkman. Recently there were found fourteen cases of scarlet fever in houses getting milk from one man. So the Board of Health offered to disinfect this man's place and all that was therein, including his cans, pails, etc., and the clothes of workers. They burned all his tickets, printed new ones, and gave orders to use the tickets only once. There was no more scarlet fever among his customers.

Why are we doctors so anxious about the milk supply? You know in the last two hundred years the death rate has been steadily lessening and the average length of life has been as steadily advancing. We live now, on an average, twice as long as the people did two hundred years ago. The death rate in Ontario in 1903 was only 13.4 per 1,000. But there is one exception to all this, and that is infantile mortality. The death rate of the young is little, if any, better than it was a century ago. What is the cause of this? First, that infants in too many cases are not nursed by their mothers. The baby nursed by its mother has fifteen chances for life against the one chance of the baby fed in any other way, and the reason that infants are not nursed by their mothers is largely that mothers do not know what a difference this makes to the welfare of the child. The second reason of the great infantile mortality is to be found in the character of the milk supply. Clean milk is hard to get, and infants do not thrive on dirty milk. You cannot be sure of getting pure milk, unless you wake up and ask for it.

I have visited dairies on the north, on the east, and on the west of Toronto, and, while some of them are much better than others, I have not yet found one that is what I would call clean. The hands, clothes, and utensils are not as we would all like to see them, and I repeat that the responsibility for this is chiefly with the consumer. We must ask for clean milk, and we must not be willing to pay as much for dirty milk as for clean.

I will ask your permission to conclude by reading an extract on this subject from the *British Medical Journal*: "Like so many other matters affecting the welfare of children and determining, therefore, whether our race is to deteriorate or improve, this (the clean milk problem) is largely a woman's question. As the writer on the milk supply of towns truly observes, 'One cannot repeat too often that with mothers and house-keepers lies the handling of this national problem. Let them refuse to deal in any shop without first visiting the farm or farms supplying that shop.' This seems simple enough and not unreasonable to ask."

If a few ladies in every town would take up the question, would insist on their milkman telling them where the milk they give their children comes from, and would give a day or two to visiting farms, we believe, as far as the milkmen who supply the wealthier classes are concerned, the problem would solve itself—we had almost said in a month. And we do not believe that these ladies, having set their own milk supply in order, would rest content until they had effected a like reform for the milk supplied to the poor. It is really a question of supply and demand;

if the housekeepers insist upon having clean milk it will be supplied. And it will be supplied at the same price to the public, and at much the same rate of profit to farmer and milkman as now. This has been amply proved by the experience of a few companies. We appeal to women to look into the facts and to act; and to act before next summer.

THE COOLING OF MILK.

While cleanliness is a necessary factor in the furnishing of a first-class milk supply, it is essential that it be quickly and thoroughly cooled if we are to produce a raw material of the desired quality. The necessity for cleanliness is readily appreciated, but the importance of cooling is too often overlooked and neglected.

Under the best conditions the milk will contain some bacteria. These germs, unless checked in their growth, injure or destroy the milk. For their growth they require food, moisture and warmth. The milk at the temperature as drawn from the cow, provides all these favorable conditions, and a rapid growth of bacteria takes place, producing sourness, bad flavors, and destroying much of the value of the milk as a food, unless quickly cooled to a temperature too low for the rapid growth of bacteria. Milk should be cooled to at least 55 or 60° Fahrenheit.

One of the most general methods adopted for cooling milk is to place the cans in a vat containing water which reaches a point slightly above surface of milk. The water may be kept cool by running fresh water from well or spring through the vat, carrying off the heat as it passes the sides of the milk cans. The cold water should enter the vat at the bottom and the warm be drawn off from the top. If the water is allowed to run constantly through the vat, it is not well to have the vat contain more than from one to two times as much water as there is milk to be cooled. If the supply of water is limited and cannot be allowed to run constantly, then the volume of water should be at least two or three times the volume of the milk to be cooled. Where ice is available, the water will be kept cold by addition of ice instead of cold water, and the volume of water should not be more than that of the milk to be cooled.

The milk should be stirred occasionally, but not vigorously, while being cooled. It would hasten cooling to insert in the centre of the milk a barrel-shaped can containing cold or ice water.

Arrange the details of your cooling method to suit individual circumstances, keeping in mind the necessity for removing the animal heat quickly and cooling to as low a temperature as your water or ice will permit. Cool, and cool quickly.

Insist upon all your co-patrons cooling carefully. Every can of milk entering a lot of cheese or butter should be properly cooled if the make is to be of high standard. One can of inferior milk will spoil the fine

flavor of the whole. One make of poorer grade than the standard of the factory will affect adversely the reputation of that factory.

Eternal vigilance will be the price of our advance to and maintenance of the first place as producers of high class dairy products.

TREATMENT OF MILK BY THE HOUSEWIFE.

The careful and thoughtful housewife will see to it that the milk which has been produced under desirable conditions and thoroughly cooled, is taken proper care of from the time it is delivered until placed on the table or used for cooking purposes. Immediately milk is received by the consumer it should be put in a cool place, on ice if possible, and kept cool until a portion or all of it is used. Do not open a bottle until you intend to use the milk, and avoid disturbing the milk after it has been opened unless absolutely necessary. The more it is handled or poured from one vessel to another, the more quickly it will lose flavor and become sour. Milk is ever ready to absorb flavors, and odors from surrounding substances. Placing it where it will be exposed to odors from vegetables, fruit, meat, etc., should be avoided.

The careful mistress need not be warned to protect milk from dust, and to keep it out of the sun. Even the painstaking mistress sometimes forgets that dust is a greater injury to milk than to any other food. Every particle of dust which falls on the surface of milk carries with it bacteria which will develop rapidly in their new home and assist in the work of destruction. The whole body of milk is no better than the poorest portion going to make it up. Be very careful, therefore, not to mix new milk with old. It is wise to keep milk that has been opened, by itself until used. Have several small pitchers instead of one or two large ones for keeping the milk in. It is well always to make a practice of scalding and cooling the vessel just before the milk is placed in it, unless you are certain that it has been properly cleansed and kept in a place free from dust since last used. It is a commendable practice to keep certain vessels for exclusive use as milk receptacles.

If milk is kept in a pitcher or other open vessel it should be covered with a damp cloth; and with the end of this cloth placed in a vessel of water, the evaporation from it will continue and assist in keeping the milk cool.

Ropey milk is sometimes caused by leaving the milk exposed to dust and heat, or emptying into a vessel which has not been properly cleaned.

Every precaution as to cleanliness and thorough cooling should be practised with the milk to be used in feeding infants, or young children, as a large proportion of the diet is in many cases composed of milk. Unless it is kept cool and sweet it is sure to affect the health of the child.

The two essentials are *cleanliness* and *proper cooling*.

Ontario Department of Agriculture.

LIVE STOCK BRANCH.

THE SHEEP INDUSTRY IN ONTARIO.

Statistics collected by the Ontario Bureau of Industries have shown for a number of years past that the rearing of sheep, has not commanded the attention of Ontario farmers to the same extent as this important branch of animal husbandry formerly did. In order to find out exactly how greatly the sheep industry has been affected a comparison was made of the number of horses, cattle, sheep and swine on hand and sold or slaughtered in the Province of Ontario during the last five years for which figures were available. The information thus secured is given in Tables I., II. and III., together with the average yearly increase or decrease, and in Table III. the per cent. of the total increase or decrease by counties is also given.

TABLE I.—Showing the number of each class of live stock in farmers' hands on July 1st of each of the last five years, and the average yearly increase or decrease.

Year.	Horses.	Cattle.	Sheep.	Swine.
1905	672,781	2,889,503	1,324,153	1,896,460
1904	655,555	2,776,304	1,455,482	1,927,984
1903	639,581	2,674,261	1,642,726	1,977,386
1902	626,106	2,562,584	1,715,513	1,684,635
1901	620,343	2,507,620	1,761,799	1,491,885
Average yearly Increase	13,109	95,471	.....	101,144
Decrease	.....	.....	109,411	.....

TABLE II.—Showing the number of each class of live stock sold or slaughtered during each of the last five years ending on June 30th, and the average yearly increase or decrease.

Year.	Horses.	Cattle.	Sheep.	Swine.
1905	62,588	714,007	603,736	2,267,583
1904	62,310	730,212	687,144	2,240,083
1903	61,967	719,911	727,850	2,168,598
1902	54,538	673,544	732,994	1,991,907
1901	50,755	610,920	729,148	1,973,405
Average yearly Increase	2,958	25,722	.....	73,544
Decrease	.....	.....	31,353	.....

TABLE III.—Showing by Counties the number of sheep on hand July 1st of each of the years stated; also the average yearly increase or decrease and the per cent. of the total increase or decrease.

County.	1901.	1902.	1903.	1904.	1905.	Average yearly increase (+) or decrease (—)	Per cent. of total increase (+) or decrease (—)
Essex	20,031	17,677	15,476	15,735	14,766	—1,316	—26.2
Kent	43,766	41,025	34,244	26,215	20,202	—5,891	—53.8
Elgin	50,744	46,226	41,316	34,084	31,238	—4,876	—38.4
Norfolk	27,837	27,639	27,727	21,151	14,395	—3,360	—48.3
Haldimand	24,789	21,842	20,986	18,654	16,338	—2,113	—34.1
Welland	19,269	17,467	17,907	14,014	10,840	—2,107	—43.8
Lincoln	14,799	12,016	10,772	11,073	12,148	— 633	—17.9
Wentworth	19,157	15,699	17,579	17,469	17,498	— 415	— 8.6
Lambton	45,077	38,363	39,297	36,604	36,144	—2,233	—19.8
Middlesex	57,267	55,738	46,034	39,496	40,596	—4,168	—29.1
Oxford	18,436	18,066	16,890	13,603	13,054	—1,345	—29.2
Brant	20,580	22,745	22,439	19,876	15,174	—1,351	—26.3
Wellington	91,147	87,377	81,745	79,499	70,390	—5,194	—22.8
Waterloo	25,896	23,526	21,133	15,111	12,566	—3,322	—51.5
Perth	42,312	40,347	34,455	28,713	22,985	—4,832	—45.7
Huron	90,870	83,175	75,902	54,426	53,710	—9,290	—40.9
Bruce	111,225	108,301	104,651	93,605	80,583	—7,660	—27.5
Grey	136,711	140,319	137,130	118,250	105,634	—7,769	—22.7
Simcoe	105,217	107,877	107,204	93,772	82,088	—5,782	—22.0
Dufferin	40,810	43,520	45,179	41,562	39,356	— 363	— 3.5
Halton	21,729	20,137	20,513	17,975	15,557	—1,543	—28.4
Peel	21,212	19,605	19,611	19,599	18,640	— 643	—12.1
York	43,460	38,866	35,206	31,493	33,031	—2,607	—24.0

TABLE III.—*Continued.*

County.	1901.	1902.	1903.	1904.	1905.	Average yearly in- crease (+) or de- crease (—)	Per cent. of total in- crease (+) or de- crease (—)
Peterborough....	30,741	34,489	33,612	26,408	22,946	—1,949	—25.4
Victoria.....	54,828	56,749	55,036	46,823	39,211	—3,904	—28.5
Ontario	58,872	56,976	52,631	46,497	42,654	—4,054	—27.5
Durham.....	42,929	38,481	37,075	35,489	33,636	—2,323	—21.6
Northumberland.	27,561	27,869	24,733	22,981	21,993	—1,392	—20.2
Prince Edward ..	7,736	6,859	7,183	7,388	7,917	+ 45	+ 2.3
Hastings	49,127	49,986	48,623	43,885	43,057	—1,517	—12.3
Lennox and Ad- dington	25,859	27,033	25,045	22,757	17,668	—2,048	—31.7
Frontenac	28,886	26,260	27,967	30,934	24,422	— 116	— 1.6
Leeds	17,827	14,677	14,372	15,739	14,449	— 883	—18.9
Grenville.....	11,903	19,040	10,204	7,580	5,836	—1,517	—50.9
Dundas	10,724	9,647	7,803	5,981	4,425	—1,575	—58.7
Stormont.....	9,397	8,597	7,025	7,725	8,667	— 182	— 7.8
Glengarry	16,518	13,201	12,702	10,374	10,253	—1,316	—37.9
Prescott.....	14,904	15,762	15,243	15,942	15,206	+ 75	+ 2.3
Russell	13,841	14,873	12,116	9,284	7,701	—1,535	—44.4
Carleton	29,459	26,933	25,581	19,537	16,936	—3,131	—42.5
Lanark.....	51,710	52,581	53,974	47,524	40,541	—2,792	—21.6
Renfrew	71,421	72,263	70,284	67,133	64,332	—1,772	— 9.9
Haliburton.....	11,799	13,124	12,298	10,944	10,362	— 359	—12.2
Muskoka.....	22,539	24,353	25,241	24,214	22,710	+ 43	+ .7
Parry Sound	24,976	26,505	27,429	26,575	24,206	— 192	— 3.1
Nipissing.....	1,755	2,812	3,479	4,665	5,447	+ 923	+210.3
Manitoulin	23,452	25,756	25,556	22,211	21,888	— 391	— 6.6
Algoma	10,697	12,034	14,019	14,913	16,757	+1,515	+56.6
Thunder Bay .. }							
Rainy River... }							

It will be noticed by Tables I. and II. that for horses, cattle and swine, there have been substantial yearly increases in numbers both of the animals on hand and of those sold and slaughtered, while for sheep the decrease in numbers has been most pronounced.

Table III. indicates that the decrease has been quite general throughout the whole Province, excepting the northern part. The only counties in the older settled portion of Ontario to show increases are Prince Edward and Prescott. In northern Ontario the Districts of Muskoka, Nipissing, Algoma, Thunder Bay and Rainy River show increases in the number of sheep, while in Manitoulin and Parry Sound the decreases are only slight. It should be noted that the counties in this table are arranged so that those having climatic and other conditions somewhat similar follow each other. The

same arrangement is made in all the other tables where figures are given by counties.

With a view to collecting and afterwards making public as much detailed information as possible regarding the sheep industry, the Department of Agriculture prepared a circular for distribution among the farmers of the Province. This circular drew attention to the decrease in the numbers of sheep and contained the parts of the Act for the Protection of Sheep and to Impose a Tax on Dogs, which directly affected the sheep breeder or dog owner. The circular also contained a list of pertinent questions which those receiving the circular were asked to answer as fully as it was in their power to do, and forward the answers to the Department. The questions to which replies were asked were as follows:

1. What proportion of farmers in your locality keep sheep?
2. What is the average size of the breeding flock?
3. Taking one year with another, how do the profits from sheep compare with profits from other classes of live stock, (a) horses, (b) cattle, (c) swine?
4. Give any special reasons why the numbers of sheep have been decreasing each year as shown by the tables on page 1.
5. Have you experienced any trouble from dogs?
6. Is a tax imposed on dogs in your township, town or village?
7. If not, has a petition been presented to your Council in accordance with Section 2 of the Act, asking that a tax be not collected?
8. In the interests of the breeders of sheep, should any change be made in the "Act for the Protection of Sheep and to Impose a Tax on Dogs"?

About eight hundred sets of replies were sent in. They came from practically every part of the Province in which farming is carried on to any considerable extent. The replies do not indicate that conditions vary greatly in the different districts of the Province, so it is not considered necessary to deal with each county individually. The views of correspondents as expressed in reply to the questions asked have furnished, unless otherwise stated, the information contained in the following pages.

For convenience and in order to economize space, the summary of replies to questions 1 and 2 have been tabulated with the information gathered from the answers to question 3.

TABLE IV.—Showing by Counties the percentage of farmers who keep sheep, the average number of sheep in each breeding flock, and the percentage of correspondents who consider the profits from sheep to be more than, the same as, or less than the profits from horses, cattle or swine.

County	Per cent. of farmers who keep sheep.	Average number of sheep in the breeding flock.	Per cent. of Correspondents stating that sheep give :—								
			More profits than horses	Same profits as horses.	Less profits than horses	More profits than cattle.	Same profits as cattle.	Less profits than cattle	More profits than swine.	Same profits as swine.	Less profits than swine.
Essex	15	12	55	12	33	55	12	33	37	13	50
Kent	8	12	75	13	12	75	13	12	66	11	23
Elgin	23	14	40	30	30	44	33	23	22	22	56
Norfolk	13	10	40	40	20	50	25	25	60	20	20
Haldimand	49	12	38	46	16	43	43	14	42	50	8
Welland	15	13	33	50	17	57	43	.....	57	29	14
Lincoln	36	16	78	22	.....	78	22	.....	56	33	11
Wentworth	9	14	43	.....	57	43	.....	57	50	.....	50
Lambton	22	14	38	38	24	38	46	16	42	58	.....
Middlesex	19	12	79	14	7	100	.....	.....	92	8	.....
Oxford	10	10	17	50	33	20	40	40	.....	60	40
Brant	17	17	80	.....	20	80	.....	20	60	.....	40
Wellington	55	13	46	16	38	46	16	38	38	16	46
Waterloo	33	10	.....	20	80	.....	40	60	.....	20	80
Perth	18	9	75	.....	25	75	.....	25	75	.....	25
Huron	33	10	30	40	30	46	30	24	20	50	30
Bruce	51	12	20	60	20	32	55	13	31	50	19
Grey	56	15	32	42	26	33	45	22	32	42	26
Simcoe	58	13	36	50	14	43	43	14	33	40	27
Dufferin	62	16	20	40	40	20	40	40	20	40	40
Halton	48	17	.....	100	.....	.....	100	.....	.....	100	.....
Peel	36	10	50	.....	50	50	.....	50	50	.....	50
York	28	14	22	67	11	22	78	.....	20	60	20
Peterborough ..	31	12	25	50	25	20	60	20	25	50	25
Victoria	49	15	57	29	14	57	29	14	50	33	17
Ontario	51	15	50	33	17	50	33	17	50	33	17
Durham	54	15	25	50	25	25	50	25	25	50	25
Northumb'land	19	12	20	70	10	20	70	10	20	70	10
Prince Edward ..	54	13	44	44	12	56	33	11	44	44	12
Hastings	6	17	.....	.....	.....	.....	.....	.....	.....	.....	.....
Lennox & Add.	18	17	25	62	13	22	44	34	25	50	25
Frontenac	44	19	33	67	.....	33	67	.....	33	67	.....
Leeds	11	12	25	50	25	25	50	25	25	50	25
Grenville	8	9	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dundas	8	8	33	33	34	29	28	43	17	50	33
Stormont .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Glengarry	9	8	.....	100	.....	.....	100	.....	50	50	.....
Prescott	18	10	20	40	40	20	40	40	20	40	40
Russell .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Carleton	8	12	40	60	.....	40	60	.....	40	60	.....
Lanark	65	13	25	50	25	25	50	25	25	50	25
Renfrew	69	23	40	40	20	40	40	20	40	40	20
Haliburton	77	12	80	20	.....	83	17	.....	50	50	.....
Muskoka	48	15	25	38	37	43	43	14	43	29	28
Parry Sound ...	61	14	50	50	.....	41	53	6	38	56	6
Nipissing	5	8	.....	.....	.....	.....	.....	.....	.....	.....	.....
Manitoulin	85	22	75	25	.....	62	38	.....	75	25	.....
Algoma	55	13	63	25	12	67	22	11	67	22	11
Thunder Bay ..	17	13	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rainy River .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Province	34	13	40	39	21	42	38	20	39	38	23

The figures were not complete enough from some of the counties and districts to allow of their being used. It will be noticed that for the whole Province 34 per cent., or about one-third, of the farmers keep sheep, and the average size of the breeding flock is thirteen sheep. For the whole Province 40 per cent. of the correspondents consider sheep more profitable than horses; 39 per cent. say that the profits are about the same, and 21 per cent. say that sheep are not so profitable as horses. Forty-two per cent. considered the profits from sheep greater than those from cattle; 28 per cent. considered that they give the same profit, and 20 per cent. think that the profits are less. In comparing the profits from sheep and swine 39 per cent. of the correspondents say that sheep are more profitable; 38 per cent. consider them equal, and 23 per cent. say that swine are more profitable than sheep.

It may be well to note the opinions expressed by some of the correspondents with regard to the profits on sheep. A correspondent from the eastern part of the Province says:

"I cannot give exact figures, but I keep sheep as well as horses, cattle and hogs, and I consider a small flock well kept and well bred pays as well as any kind of live stock, and requires less labor."

A farmer from Perth County writes as follows:

"There is more profit in sheep than any other animal on the farm, but farmers have been careless and allowed them to take care of themselves. There is one thing that must not be neglected in keeping sheep; that is, they must be kept in a close field in the fall, so that no ram can get near them till the end of November. Then the lambs will come on the grass and none will be lost, and you have no trouble; otherwise, lambs will come in cold weather, and half of them die, and you have to slop the ewes and nurse the lambs till they cost more than they are worth. The early lambs are the largest in July and August, but when October comes the lambs that came in May are the best, for the reason that they were not stunted at first. Sheep and cows should not be kept in the same pasture field. When the cows have finished the field sheep can be turned in and left for a week or two and then follow the cows in another field, and so on. Sheep and horses are all right together. Another thing in favor of sheep is that they can make a living on the fields two or three weeks longer in the fall, and can be turned out two or three weeks earlier in the spring than any other animal, and they will kill all burdocks and many other weeds. They are easier handled in the winter, and you can feed grain whole to them, thus saving the expense of having it chopped, as you have to do for most other animals."

From Elgin County comes the following communication:

"There is more profit in sheep for the small amount invested than anything else, and less bother. There are several reasons for the decline of the sheep industry in this locality. (1) Within the last few years dairying has become so profitable that farmers are keeping all the cows their pastures will carry. Those who do keep sheep have only a limited number with the object of having weeds and other noxious growth kept down. (2) Some farmers who would otherwise keep a flock of sheep claim that they soil the pasture so that cattle will not eat it, and as they have no other available system of management, they have to dispense with the sheep. (3) A local by-law passed by the township council four or five years ago prohibiting sheep running on the high-

way has also limited the area of pasture formerly devoted to sheep in the district. Not a few farmers who used to let a small flock pasture on the roads have been forced to get rid of the sheep."

A correspondent from Lanark County says:

"I think at the present time, when help is so scarce and wool and lambs a good price, that sheep head the list as regards profits."

In connection with the consideration of the relative profits from cattle, sheep and swine, the following table will be of interest. This table shows the highest prices quoted on the Toronto market early in July, September and November for the last ten years for cattle, sheep (not lambs) and swine. It is considered that the bulk of the sheep are marketed between July 1st and December 1st.

TABLE V.—Showing the highest prices quoted on the Toronto market for cattle, sheep and swine early in July, September and November, for the last ten years.

Date.	Cattle.	*Sheep.	Swine.
	Per cwt.	Per cwt.	Per cwt.
1897—July	\$4 25	\$3 50	\$5 65
September	4 55	3 37	6 00
November	4 00	3 20	<u>4 75</u>
1898—July	4 75	4 00	5 20
September	4 60	3 45	5 25
November	4 35	3 25	<u>4 25</u>
1899—July	5 15	3 90	5 00
September	5 00	4 00	5 37
November	4 80	3 25	<u>4 37</u>
1900—July	5 35	4 25	6 50
September	5 12	4 00	6 25
November	4 45	3 25	5 50
1901—July	5 20	4 25	<u>7 00</u>
September	5 12	4 00	7 25
November	4 75	3 44	6 00
1902—July	7 00	3 60	<u>6 87</u>
September	6 00	3 65	7 25
November	4 75	3 15	6 00
1903—July	5 25	4 00	<u>5 75</u>
September	4 80	3 60	6 50
November	4 85	3 40	5 40
1904—July	5 75	3 90	<u>5 10</u>
September	5 00	3 75	5 60
November	4 75	3 50	<u>4 90</u>
1905—July	5 35	3 90	6 65
September	4 95	4 15	7 10
November	4 65	4 25	<u>6 00</u>
1906—July	5 30	4 50	7 25
September	4 95	4 65	6 90
November	4 80	4 65	<u>6 25</u>
1907—July	6 25	5 25	6 75

* For prices quoted on lambs, see Table VI.

During the last two years there has been a gradual improvement in the price for sheep. To the casual observer the above figures are not favorable to the sheep when compared with other classes of stock. In comparing the prices, however, it must be borne in mind that sheep as a rule do not require nearly so much expensive feed, the labor bill is less and the equipment for housing and caring for them does not require nearly so large an investment. Another important consideration is the value of the fleece, which at the present price for wool would add about \$1 per hundred to the above prices for sheep. Also note the following table, which shows the variations in prices on the Toronto market for each class of sheep and lambs for the same years and dates as the previous table.

TABLE VI.—Showing the variations in prices quoted on the Toronto market for the principal classes of sheep.

Date.	Exporters.		Butchers' stock and Bucks.		Lambs.	
	High.	Low.	High.	Low.	High.	Low.
	Per cwt.	Per cwt.	Per cwt.	Per cwt.	Each.	Each.
1897—July	\$3 50	\$3 25	\$3 25	\$2 50	\$4 50	\$3 50
September	3 40	3 00	3 00	2 50	3 50	2 75
November	3 20	3 00	2 75	2 25	*4 00	*3 80
1898—July	4 00	....	3 25	2 75	4 75	4 00
September	3 45	3 25	2 75	2 25	4 00	3 50
November	3 25	3 00	2 50	2 00	3 50	2 75
1899—July	3 90	3 75	3 00	2 75	4 25	3 00
September	4 00	3 75	3 00	2 75	4 50	3 00
November	3 25	3 00	2 50	2 00	*3 75	*3 50
1900—July	4 25	3 75	3 50	3 25	4 25	2 50
September	4 00	3 75	3 00	2 75	4 00	3 00
November	3 44	3 25	3 00	2 75	3 50	2 50
1901—July	3 60	3 50	3 00	2 50	4 00	2 50
September	3 65	3 50	3 00	2 50	*5 00	*4 25
November	3 15	3 00	2 50	2 00	3 00	2 50
1902—July	4 00	3 50	3 00	2 75	4 00	2 50
September	3 60	3 40	2 75	2 50	4 50	4 00
November	3 40	3 25	2 75	2 50	*3 50	*3 00
1903—July	3 90	2 75	3 50	2 50	4 50	3 50
September	3 75	3 50	3 00	....	*4 60	....
November	3 50	3 40	2 75	2 50	4 00	3 50
1904—July	4 15	3 85	3 25	3 00	4 50	3 50
September	3 75	3 65	3 25	3 00	4 90	4 50
November	3 50	2 50	3 50	2 00	4 50	4 00
1905—July	3 90	3 00	3 50	2 50	5 25	3 50
September	4 15	3 00	4 00	3 00	6 10	5 50
November	4 25	4 00	3 50	3 00	6 10	5 50
1906—July	4 50	4 25	4 00	3 50	6 25	4 00
September	4 65	4 40	3 75	3 50	*7 00	*6 00
November	4 65	4 25	3 75	3 50	*5 65	*5 00
1907—July	5 25	5 00	4 50	3 50	8 00	6 00

* These prices are per hundred weight.

The market reporter frequently draws attention to the fact that the bulk of export sheep marketed are ewes, noting the scarcity of wethers. Many of the male sheep are being marketed as bucks, and as such are classed with the cheaper grades of sheep.

The table below gives the Toronto quotations for both washed and unwashed wool during the months of May, June and July for the last ten years.

TABLE VII.—Showing the prices quoted on the Toronto market early in each of the following months for the last ten years for both unwashed and washed wool.

Date.	Unwashed Wool.		Washed Wool.	
	High.	Low.	High.	Low.
	per pound. cents	per pound. cents	per pound. cents	per pound. cents
1898—May	12	11½	16	.....
June	11½	11	16	.....
July	11	.....	16	.....
1899—May	8½	.....	13	.....
June	9	8	14	13
July	8½	.....	14	.....
1900—May	10½	.....	16	15
June	10	9	15½	15
July	10	.....	16	.....
1901—May	9	8	15	14
June	8	.....	13	.....
July	8	.....	13	.....
1902—May	7	.....	12½	.....
June	7	.....	12	.....
July	7	.....	13	.....
1903—May	8	.....	15	.....
June	9	8	15½	14½
July	8½	8	17	15
1904—May	10	9	16	15
June	10½	9½	17	16
July	13	12	17	16
1905—May	14	13	22	.....
June	14	.....	22	.....
July	15	.....	23	.....
1906—May	17	16	25	.....
June	18	16	26	.....
July	18	16	27	26
1907—May	14	.....	24	.....
June	14	13	24	.....
July	14	13	24	23

The fourth question of the circular which asked for special reasons why the number of sheep have been decreasing brought out quite a variety of answers. The particular reasons advanced for the decrease in the number of sheep are here given in the order of frequency with which they were named by correspondents.

(1) Lack of sufficient profits due to low price of mutton and wool, or to the comparatively high prices for other kinds of stock or their products, particularly dairy cattle and their products, together with bacon hogs.

(2) Losses caused by dogs killing, wounding or worrying sheep.

(3) Lack of pasture due usually to the keeping of as much other stock as the land will carry.

The passing of a by-law by municipal township councils forbidding pasturing of sheep on the public roads of the township is an important factor in producing a shortage of pasture. A considerable number of correspondents also claim that sheep foul pasture for other stock.

(4) The difficulty of properly fencing sheep in.

(5) Losses from disease and at lambing time.

Not even the most enthusiastic advocate of sheep raising will deny that the reasons given above have in the main caused the decrease in the numbers of sheep. In spite of the handicap which is thus placed upon the sheep industry the replies of correspondents indicate that instead of 34 per cent. of the farmers keeping an average flock of 13 breeding ewes as at present there should be flocks of from 10 to 20 ewes on fully 75 per cent. of the farms of Ontario. The contention is that there has been lack of appreciation of the value of sheep on the farm. To a considerable extent this has been brought about on account of the sheep being able to get along with far less care and attention than other classes of stock.

Correspondents state that while the lack of profits has been the principal reason for a decrease in the numbers of sheep in the past, the profits at the present time are such as to encourage more extensive breeding. The truth of this statement will be recognized upon referring to table IV., which gives the summary of correspondents' opinions of the comparative profits.

In order to reduce the losses caused by dogs, the general opinion is that the Act for the Protection of Sheep and to Impose a Tax on Dogs should be revised. This matter will be dealt with in considering the replies to question 8.

Regarding the number of sheep that should be kept, the following correspondents are quoted :

"The sheep industry is one of the most important that concerns the average farmer in animal husbandry, especially those having rough and broken land on their farms. Since the farm labor problem has become so serious, and the grazing of more land advisable, sheep are about the best to help the farmer out as they take little care in the winter and require the minimum storage of feed. The greatest difficulty in sheep raising has been dogs, although the present law has been of great benefit. I do not think it is quite stringent enough."

"That the number of sheep kept on our farms is bound to increase is very evident. Formerly, and I may say at present, many are keeping more cows than they can milk without more help. This is hard to secure, and as a substitute for the dairy cow the sheep is bound to lead. I do not contend that our farmers are going to abandon the dairy cow, but rather many will have to cut their herds down by a few and this will make room for a small flock of sheep. Prices for wool and mutton are now very satisfactory, very much higher than the ruling prices of a year or two ago. I think if farmers could get in some way of finishing their lambs at home and so get higher prices than they realize by turning them off in October or September it would have a wholesome effect on the sheep industry. In this township there is very little waste land that sheep could improve. Nearly all of our land is improved and very suitable for the production of all kinds of crops and this has an effect on the sheep business. A great many lack an understanding of the business as regards care and housing of the flocks."

"There seems to be a prevailing prejudice that sheep are hard on pasture. I do not think it is well founded. If farmers would only consider how easy it is to provide abundance of the very best feed for sheep by sowing rape among all their spring crops, affording a great amount of pasture all the latter part of the season at a mere nominal cost for seed. Then there is the advantage of sheep as scavengers turning the noxious weeds into money. With the scarcity and high price of farm help, and the inexpensive building required for sheep as compared with that for other stock, it would pay, and pay well, for farmers to keep very many more sheep. I am surprised to know that they are on the decrease from year to year. It seems to be the unanimous verdict of those who have experimented and kept careful tab on cost and profit, that there is nothing on the farm that pays better than a properly cared for flock of sheep."

In replying to question 5, practically every correspondent who kept sheep answered the question by stating that he had experienced trouble from dogs. In the neighborhood of villages and towns it appears to be most difficult to protect sheep from dogs, especially if the so-called "bird dogs" are numerous.

In answering question 6, "Is a tax imposed on dogs in your township, town or village?" and question 7, "If not, has the petition been presented to your Council in accordance with section 2 of the Act, asking that a tax be not collected?" many correspondents were unable to give definite answers. To get complete information for all the townships in the Province, the returns of municipal clerks to the Bureau of Industries have been consulted. The latest years for which figures were available were 1903 and 1904, and townships only are included, as the clerks of towns and villages do not always report on the taxing of dogs. The table following has been extended to include the amount of dog taxes collected by the townships in each county and the amount paid to sheep owners for damages done by dogs.

TABLE VIII.—Showing by Counties, for the years 1903 and 1904, the number of townships that collected dog taxes and the number of those that did not collect these taxes; the number of townships that paid for damages done to sheep by dogs and the number that did not pay damages; the amount of dog taxes collected in each County, and the amount paid for damages done to sheep by dogs.

County.	Number that collected dog taxes.		Number that did not collect dog taxes.		Number that paid for damages done to sheep.		Number that did not pay for damages done to sheep.		Amount of dog taxes collected.		Amount paid for damages done to sheep.	
	1903	1904	1903	1904	1903	1904	1903	1904	1903	1904	1903	1904
									\$	\$	\$	\$
Essex	14	14	1	1	12	12	3	3	3,451	3,547	595	633
Kent	10	10	....	....	10	10	....	....	3,958	3,875	1,670	1,416
Elgin	7	7	....	....	7	7	....	....	3,003	3,191	1,065	1,116
Norfolk	8	8	....	....	8	8	....	....	2,734	2,711	603	795
Haldimand	10	10	....	....	8	7	2	3	1,820	1,736	493	523
Welland	8	8	....	....	5	6	3	2	1,744	1,677	260	161
Lincoln	8	8	....	....	8	3	....	5	1,543	1,643	716	282
Wentworth	9	9	....	....	7	7	2	2	2,760	2,743	226	547
Lambton	10	10	....	....	9	9	1	1	4,174	4,331	1,625	931
Middlesex	15	15	....	....	14	13	1	2	5,858	5,956	1,070	816
Oxford	11	11	....	....	9	8	2	3	3,727	3,847	621	284
Brant	5	5	....	....	5	5	....	....	1,807	1,937	622	374
Wellington	4	4	8	8	....	....	12	12	1,337	1,415	....	....
Waterloo	5	5	....	....	5	5	....	....	2,597	2,641	795	468
Perth	3	3	8	8	1	2	10	9	703	785	11	69
Huron	9	9	7	7	3	3	13	13	2,183	2,164	46	78
Bruce	1	1	15	15	1	1	15	15	545	531	34	17
Grey	2	3	14	13	2	2	14	14	534	643	246	80
Simcoe	3	3	13	13	3	4	13	12	1,162	1,549	252	173
Dufferin .....	....	....	6	6	....	....	6	6	....	....	....	....
Halton	4	4	....	....	4	4	....	....	1,676	1,521	251	483
Peel	4	4	1	1	2	2	3	3	1,547	1,612	277	288
York	10	10	....	....	9	9	1	1	4,552	4,729	920	774
Peterborough	2	2	10	10	....	....	12	12	542	540	....	....
Victoria	1	....	10	11	1	1	10	10	287	....	45	15
Ontario	10	11	1	....	10	10	1	1	3,001	3,637	883	956
Durham	4	4	2	2	4	4	2	2	1,508	1,503	329	678
Northumberland ..	6	6	3	3	7	7	2	2	1,665	1,507	587	959
Prince Edward	4	4	3	3	4	4	3	3	340	348	120	83
Hastings .....	....	1	18	17	....	....	18	18	....	134	....	....
Lennox and Addington ..	4	4	6	6	4	4	6	6	901	903	105	226
Frontenac	1	1	14	14	1	1	14	14	112	229	193	66
Leeds	2	2	8	8	2	1	8	9	318	340	135	36
Grenville	1	1	4	4	3	2	3	3	426	427	61	34
Dundas	1	1	3	3	1	1	3	3	17	20	40	7
Storront .....	....	2	4	2	....	2	4	2	....	1,186	....	305
Glengarry	1	....	3	4	....	....	4	4	606	....	....	....

TABLE VIII—*Continued.*

County.	Number that collected dog taxes.		Number that did not collect dog taxes.		Number that paid for damages done to sheep.		Number that did not pay for damages done to sheep.		Amount of dog taxes collected.		Amount paid for damages done to sheep.	
	1903	1904	1903	1904	1903	1904	1903	1904	1903	1904	1903	1904
Prescott.....			7	7			7	7	\$	\$	\$	\$
Russell.....			4	4			4	4				
Carleton.....	3	3		7	2	2	8	8	660	649	193	61
Lanark.....			13	13			13	13				
Renfrew.....	2	3	20	19	2	1	20	21	394	502	128	229
Haliburton.....			10	10	1		9	10			47	
Muskoka.....	4	5	11	10	1	1	14	14	83	194	16	23
Parry Sound.....	6	5	12	13	7	3	11	15	655	565	103	53
Nipissing.....	2	4	14	12			16	16	25	118		
Manitoulin.....	2	2	7	7		1	9	8	122	153		53
Algoma.....	8	9	14	13	4	2	18	20	450	597	109	46
Thunder Bay.....	1	1	4	4			5	5	36	45		
Rainy River.....	2	4	7	5			9	9	79	168		
Province.....	227	236	292	283	186	174	333	345	65,642	68,549	15,492	14,138

The table shows that of the 519 townships in the Province, 227 townships collected dog taxes in 1903 and 236 in 1904. The townships that did not collect dog taxes numbered 292 in 1903 and 283 in 1904. The townships that did not collect dog taxes must have passed a by-law in accordance with section 2 of the Act for the Protection of Sheep and to Impose a Tax on Dogs. It will be noticed that 186 townships paid for damages done to sheep by dogs in 1903, and in 1904 those paying damages numbered 174. This would indicate that 41 townships in 1903 and 62 townships in 1904 collected taxes and did not pay for damages to sheep by dogs.

The returns made to the Department by towns and villages do not give particulars, in many cases, regarding the dog taxes. So far as the returns have been received, they show that both in 1903 and 1904 the number of towns and villages that collected a dog tax numbered 171, against 84 which did not collect taxes on dogs. The total of these taxes collected in 1903 was \$21,747, and in 1904 \$15,334. Only two of these towns and villages report the payment of money for damages done to sheep by dogs.

In discussing the Act in reply to question 8, correspondents were almost unanimous in their desire to have the Act changed so as to make it more effective in protecting the sheep interest. The Act was also discussed at the last Provincial Winter Fair before a large and representative gathering of farmers. Taking the results of this meeting and the reports of correspondents, the Dominion Sheep Breeders' Association undertook to suggest a revision of the Act so as to eliminate the weaknesses that had been pointed out. Below we publish the Act in full, together with the suggested changes as adopted by the Dominion Sheep Breeders' Association at their last annual meeting. In order that the changes may be readily understood, the parts it is suggested to omit from the Act are printed in *italics*, and the parts that it is suggested to add to the Act are printed in **black-faced type**.

THE ACT FOR THE PROTECTION OF SHEEP AND TO IMPOSE A TAX ON DOGS.

(CHAPTER 271, R.S.O. 1897.)

1. *Subject to the provision in the next following section*, there shall be levied annually, in every municipality in Ontario, upon the owner, possessor or harborer of each dog therein, an annual tax of \$1 for a (one) dog, **\$2 for each dog more than one**, and \$2 (**\$5**) for a bitch, provided, nevertheless, that the owner or possessor of a kennel of pure-bred dogs which are registered in the "Canada Kennel Register" may in any year obtain from the treasurer of the municipality a certificate of having paid to such treasurer the sum of \$10 as a tax upon such kennel for the year, and upon the production thereof to the assessor, the owner or possessor of such kennel shall be exempt from assessment and any further tax in respect thereof for the said year. 53 V., c. 62, s. 1.

Remarks: The amount of taxes that should be imposed upon dogs was a matter upon which correspondents were not agreed. The amount suggested varied from nothing to \$10 each. The majority, however, varied from \$1 to \$2 for each dog and from \$5 to \$10 for each bitch. The Association, in deciding upon the amount of taxes, kept in view the fact that useful well cared for dogs should not be heavily taxed and they consider that persons should be discouraged from keeping more than one dog. They therefore suggest that the tax be placed at \$1 for one dog and \$2 for each dog more than one. In raising the tax on bitches to \$5 and allowing the tax on kennels of pure-bred dogs to remain at \$10 the desire was to confine, as much as possible, the breeding of dogs to these kennels.

2. *Upon the petition of twenty-five ratepayers the council of any city, town, township or incorporated village may provide by by-law that the said tax or any part of it shall not be levied in said municipality.* 53 V., c. 62, s. 2; 55 V., c. 55, s. 2.

Remarks: Correspondents were of the opinion that the tax on dogs should be compulsory and that section 2 of the Act should be struck out. The meeting of the Winter Fair also passed a motion asking for compulsory taxation.

3. The assessors of every municipality *within which a by-law has not been passed as provided in the preceding section* shall at the time of making their annual assessment, enter on the assessment roll, in a column prepared for the purpose, opposite the name of every person assessed, and also opposite the name of every resident inhabitant not otherwise assessed, being the owner or keeper of any dog, the number **and sex of dogs** by him owned or kept. R.S.O., 1887, c. 214, s. 3.

4. The owner, possessor or keeper of any dog, shall, *when (be)* required by the assessors to deliver to them, in writing, a statement of the number of dogs owned or kept by him, whether one or more; and for every refusal or neglect to do so, and for every false statement made in respect thereof, he shall incur a penalty of \$5, to be recovered with costs, before any Justice of the Peace having jurisdiction in the municipality. R.S.O., 1887, c. 214, s. 4; 53 V., c. 62, s. 3.

Remarks: The changes in sections 3 and 4 are particularly for the purpose of securing a better enforcement of the Act.

5. The collector's roll of the municipality shall contain the name of every person entered on the assessment roll as the owner, possessor or keeper of any dog with the tax hereby imposed in a separate column, and the collector shall proceed to collect the same, at the same time and with the like authority, and make returns to the treasurer of the municipality, in the same manner and subject to the same liabilities in all respects for paying over the same to the treasurer as in the case of other taxes levied in the municipality. R.S.O., 1887, c. 214, s. 5; 53 V., c. 62, s. 4.

6. In cases where persons have been assessed for dogs, and the collector has failed to collect the taxes, authorized by this Act, he shall report the same under oath to any Justice of the Peace, and such Justice shall, by an order under his hand and seal, to be served by any duly qualified constable, require such dogs to be destroyed by the owners, possessors or harborers thereof, or by a constable, and for the purpose of carrying out the said order any constable may enter on the premises of the owner, possessor or harborer of the dog ordered to be destroyed and destroy such dog; and in case any collector neglects to make the aforesaid report within the time required for paying over the taxes levied in the municipality, he shall be liable to a penalty of \$10 and costs, to be recovered in the same manner as provided in section 15 of this Act. R.S.O., 1887, c. 214, s. 6; 53 V., c. 62, s. 5; 56 V., c. 46, s. 1.

7. The money collected and paid to the clerk or treasurer of any municipality under the preceding sections, shall constitute a fund for satisfying such damages, as arise in any year from dogs killing or injuring sheep or lambs in such municipality; and the residue, if any, shall form part of the assets of the municipality for the general purposes thereof; but when it becomes necessary in any year for the purpose of paying charges on the same, the fund shall be supplemented to the extent of the amount which has been applied to the general purposes of the municipality. R.S.O., 1887, c. 214, s. 7.

8. *In case the council of any city, town, township or incorporated village deems it advisable that the tax by this Act established should be maintained, but that the application of the proceeds thereof by this Act provided should*

be dispensed with, it shall be lawful for such council by by-law to declare that such application shall be dispensed with; and thereafter during the continuance of such by-law, the sections of this Act numbered 6, 7 and 17 to 21 inclusive shall have no force or effect in the municipality within the jurisdiction of such council; and the moneys collected and paid to the clerk or treasurer of the municipality under the remaining sections of this Act, shall be the property of the municipality, and shall be subject to its disposition in like manner as other local taxes. R.S.O., 1887, c. 214, s. 8 (1); 53 V., c. 62, s. 8; 55 V., c. 55, s. 1.

Remarks: As will be noticed by Table VIII., a number of municipalities which collect taxes on dogs take advantage of the above section to dispense with the payment for damages done by dogs to sheep and use the moneys so collected entirely for other purposes. The correspondents claim that this is a great injustice to the sheep owners and express the desire to have this clause repealed.

PROTECTION OF SHEEP.

9. Any person may kill—

- (a) Any dog which he sees pursuing, worrying or wounding any sheep or lamb; or
- (b) Any dog without lawful permission in any enclosed field on any farm which the owner or occupant thereof or his servant finds giving tongue and terrifying any sheep or lamb on such farm, or,
- (c) Any dog which any person finds straying between sunset and sunrise on any farm whereon any sheep or lambs are kept;

But no dog so straying which belongs to or is kept or harbored by the occupant of any premises next adjoining the said farm, or next adjoining that part of any highway or lane which abuts on said farm, nor any dog so straying, either when securely muzzled or when accompanied by or being within reasonable call or control of any person owning or possessing or having the charge or care of said dog, shall be so killed unless there is reasonable apprehension that such dog, if not killed, is likely to pursue, worry, wound or terrify sheep or lambs then on the said farm. 56 V., c. 46, s. 2.

10. The defendant in any action for damages for killing a dog under the circumstances in the preceding section mentioned may plead not guilty by statute and give this Act and the special matter in evidence. R.S.O., 1887, c. 214, s. 10.

11. On complaint made in writing on oath before a Justice of the Peace for any city, town or county, that any person residing in such city, town or county owns, or has in his possession a dog which has within six months previous worried or injured or destroyed any sheep or lamb, the Justice of the Peace may issue his summons, directed to such person, stating shortly the matter of the complaint, and requiring such person to appear before him, at a certain time and place therein stated, to answer to such complaint, and to be further dealt with according to law. R.S.O., 1887, c. 214, s. 11; 60 V., c. 45, s. 80.

12. The proceedings on such complaint and summons shall be regulated by the Ontario Summary Convictions Act, which shall apply to cases under this Act. R.S.O., 1887, c. 214, s. 12.

13. In case any person is convicted on the oath of a credible witness, of owning or having in his possession a dog which has worried or injured or destroyed any sheep or lamb, the Justice of the Peace *may* (**shall**) make an order for the killing of such dog (describing the same according to the tenor

of the description given in the complaint and in the evidence) within three days, and in default thereof *may in his discretion* (**shall**) impose a fine upon such person not exceeding \$20 with costs, and all penalties imposed under this section shall be applied to the use of the municipality in which the defendant resides. R.S.O., 1887, c. 214, s. 13; 60 V., c. 45, s. 80.

14. No conviction under this Act shall be a bar to any action by the owner or possessor, as aforesaid, of any sheep or lamb for the recovery of damages for the injury done to such sheep or lamb, in respect of which such conviction is had. R.S.O., 1887, c. 214, s. 14.

15.—(1) The owner of any sheep or lamb killed or injured by any dog shall be entitled to recover the damage occasioned thereby from the owner or keeper of such dog, by an action for damages or by summary proceedings before a Justice of the Peace, on information or complaint before such justice, who is hereby authorized to hear and determine such complaint, and proceed thereon in the manner provided by the Ontario Summary Convictions Act in respect to proceedings therein mentioned; and such aggrieved party shall be entitled so to recover in such action or proceedings, whether the owner or keeper of such dog knew or did not know that it was vicious or accustomed to worry sheep.

(2) If it appears to the court or judge at the trial of any such action for damages, or to such justice at the hearing of the said information or complaint before him, that the damage or some part of the damage sustained by such aggrieved party was the joint act of some other dog or dogs, and of the dog or dogs owned or kept by the person charged in such information or complaint, the court, judge or justice shall have power so to decide and to apportion the damages sustained by the complainant, among and against the respective owners or keepers of the said dogs, as far as such owners or keepers are known, in such shares and proportions as such court, judge or justice thinks fit, and to award the same by the judgment of the said court or judge, or in the conviction of such justice on behalf of such aggrieved person.

(3) When in the opinion of the court, judge or justice, the damages were occasioned by dogs the owner or owners of which are known, and dogs the owner or owners of which are unknown, or the owner or owners of which have not been summoned to appear before the court, judge or justice, the court, judge or justice may decide and adjudge as to the proportion of the damages which, having regard to the evidence adduced as to the strength, ferocity and character of the various dogs shown to have been engaged in committing such damage, was probably done by the dogs the owner or owners of which have been summoned to appear before the court, judge or justice and shall determine in respect thereof and apportion the damages which the court, judge or justice decides to have been probably done by the dogs whose owners have been summoned, amongst the various owners who have been summoned as aforesaid.

(4) The same proceedings shall thereupon be had against any person found by the court, judge or justice to be the owner or keeper of the dogs which by such court, judge or justice, are found to have contributed to the damage sustained by the person aggrieved, as if the information or complaint had been laid in the first instance against such person.

(5) The court, judge or justice shall not decide and apportion the damage against any person other than the person in the information or complaint first charged, nor award the same in the judgment or conviction without such other person having been summoned to appear before the court, judge or justice, and having had an opportunity of calling witnesses.

(6) Appeals against any conviction, apportionment or order made by a justice of the peace under this section, shall be made to the Division Court holden in the division in which the cause of action arose, or in which the party

complained against or one of them, resided at the time of making the complaint; and the proceedings shall be the same or nearly as may be as on appeals under the Act respecting Master and Servant. R.S.O., 1887, c. 214, s. 15.

16. The owner or keeper of any dog or dogs, to whom notice is given of any injury done by his dog or dogs to any sheep or lamb, or of his dog or dogs having chased or worried any sheep or lamb, shall, within forty-eight hours after such notice, cause such dog or dogs to be killed, and for every neglect so to do he shall forfeit a sum of \$2.50 for each dog and a further sum of \$1.25 for each such dog for every forty-eight hours thereafter until the same is killed if it is proved to the satisfaction of the justice of the peace before whom proceedings are taken for the recovery of such penalties that such dog or dogs has or have worried or otherwise injured such sheep or lambs; but no such penalties shall be enforced in case it appears to the satisfaction of the justice of the peace that it was not in the power of the owner or keeper to kill such dog or dogs. R.S.O., 1887, c. 214, s. 16.

17. In case the owner of any sheep or lamb so killed or injured proceeds against the owner or keeper of the dog that committed the injury, before a justice of the peace, as provided by this Act, and is unable on the conviction of the offender to levy the amount ordered to be paid, for want of sufficient distress to levy the same, then the council of the municipality in which the offender resided at the time of the injury shall order their treasurer to pay to the aggrieved party **not less than two-thirds** of the amount ordered to be paid by the justice under the conviction in addition to the costs of the proceedings before the justice and before the council. R.S.O., 1887, c. 214, s. 17; 53 V., c. 62, s. 7.

Remarks: The above change would permit the officials of the municipality to use their judgment as to whether they should pay the full amount of the damage sustained, but it makes it compulsory for them to pay at least two-thirds value. A great many correspondents wish to have it made compulsory upon the municipality to pay damages in full, but a number of correspondents drew attention to the fact that in some cases the municipality is imposed upon, and the Association therefore decided on the above basis for payment.

17a. The Council of each township, town or village, shall at their first meeting each year appoint one or more competent persons, to be known as Sheep Inspectors, whose duty it shall be to inspect the injury done to sheep by dogs in cases where the owner or keeper of the dog or dogs committing the injury cannot be found, and the aggrieved party intends to make claim for compensation from the council of the municipality. Said appointee shall investigate the injury within 48 hours after the notice is given to him and forthwith make his report in writing to the Clerk of the Council as early as possible after the investigation, giving in detail the extent of injuries and amount of damage done. This report shall be used by the council as evidence in adjusting the claim.

Remarks: In order to avoid the imposition by sheep owners as referred to in the remarks following section 17, and in order to secure a proper valuation of the damage done, it is considered advisable that the above section should be made a part of the Act. In at least one of the townships of the Province they have sheep inspectors at the present time and their work has been reported to be quite satisfactory both to the

township and to the sheep owners. In the township referred to the following is the procedure in case of damage done by dogs :

1st. The inspector is notified by the owner of the sheep as soon as possible after the damage is discovered.

2nd. The inspector makes enquiry of the owner of the sheep if the dog or dogs that did the damage are known to him. If they are not it is then the duty of the inspector to see the sheep and to decide whether the damage has been done by dogs or not.

3rd. In case any of the sheep are dead or are so damaged that they are not likely to recover, the inspector proceeds to examine them as to age, size and breeding and then values them according to what such sheep would bring in the market at the time, taking into consideration whether they are of the mutton class or breeding stock.

4th. Those which are only injured the inspector may not decide upon the amount of damage until a second inspection at a later date.

5th. The fee paid by the council to the inspector is \$1 for each call.

6th. The territory of an inspector is one polling subdivision.

The following is a copy of the form used by the sheep inspector in making his report to the council :

REPORT OF SHEEP INSPECTOR.

Polling Subdivision No.

To the Reeve and Council of the Corporation of the Township of

Gentlemen,—This is to certify that of Lot, Concession, had sheep and lambs worried by a dog or dogs on or about 19...; that I was notified of the damages on 19...; that I inspected the damages personally on 19...; and beg leave to report as follows:

1st. That the sheep and lambs were owned by claimant.

2nd. That the sheep and lambs were on the enclosed premises of owner.

3rd. That the sheep and lambs were worried by a dog or dogs.

4th. That the owners of the dogs have not been ascertained.

That I assess the damage as follows:

..... Sheep killed, valued at \$..... each, total	\$.....
..... Lambs killed, valued at \$..... each, total	\$.....
..... Sheep injured, damages \$..... each, total	\$.....
..... Lambs injured, damages \$..... each, total	\$.....

Total damages	\$.....
Deductions for skins and wool if saved	\$.....

Net total damages	\$.....
Less one-third as provided by statutes	\$.....

Net total claim	\$.....
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Certified as correct.

Dated 19.... Inspector.

18. **Subject to the provisions in the next following section, the owner of any sheep or lamb killed or injured by any dog, the owner or keeper of which is not known, may within three months after the killing or injury apply to the council of the municipality in which such sheep or lamb was so killed or injured, for compensation for the injury; and if the council (any member of which shall be competent to administer an oath or oaths in examining parties in the premises) is satisfied that the aggrieved party has made diligent search and inquiry to ascertain the owner or keeper of such dog, and that such owner or keeper cannot be found, they shall award to the aggrieved party for compensation a sum *not exceeding of not less than* two-thirds of the amount of the damage sustained by him; and the treasurer of the municipality pay over to him the amount so awarded. R.S.O., 1887, c. 214, s. 18.**

Remarks: The change made in this section is one corresponding to the one made in section 17.

18a. The owner of any sheep or lamb, killed or injured, who intends to claim compensation from the Council of the municipality shall notify the Sheep Inspector in person, or in writing, within 48 hours after the injury is committed.

Remarks: The limit of 48 hours within which time the sheep inspector must be informed of the injury done appears to be a necessary regulation in order that the inspector may make an accurate estimate of the injury done. It will be noticed in section 17a that the inspector is allowed 48 hours within which to perform his duty after the notice is given him.

19. After the owner of such sheep or lamb has received from the municipality any money under either of the preceding sections, his claim shall thenceforth belong to the municipality; and they may enforce the same against the offending party for their own benefit, by any means or form of proceeding that the aggrieved party was entitled to take for that purpose, but in case the municipality recovers from the offender more than they had paid to the aggrieved party, besides their costs, they shall pay over the excess to the aggrieved party for his own use. R.S.O., 1887, c. 214, s. 19.

20. The owner of any sheep or lamb killed or injured while running at large upon any highway or unenclosed land, shall have no claim under this Act to obtain compensation from any municipality. R.S.O., 1887, c. 214, s. 20.

21. *If the council of any city, town, township or incorporated village by by-law decides to dispense with the levy of the aforesaid tax in the municipalities within its jurisdiction, the owner of any sheep or lamb may, notwithstanding, sue the owner or keeper of any dog or dogs for the damage or injury done by the said dog or dogs to the said sheep or lamb; and the same shall be recovered in the manner provided by section 15 of this Act. R.S.O., 1887, c. 214, s. 21; 53 V., c. 62, s. 8.*

Remarks: This clause is dependent upon section 8, so that if section 8 is struck out there is no necessity for section 21.

22. Every justice of the peace shall be entitled to charge such fees in cases of prosecutions or orders under this Act, as it is lawful for him to charge in other cases within his jurisdiction, and he shall make the returns usual in cases of conviction, and also a return in each case to the clerk of the municipality, whose duty it shall be to enter the same in a book to be kept for that purpose. R.S.O., 1887, c. 214, s. 22.

SHEEP BREEDING IN ONTARIO.

By JOHN CAMPBELL, PRESIDENT DOMINION SHEEP BREEDERS' ASSOCIATION,
FAIRVIEW FARM, WOODVILLE, ONT.

Sheep are again in favor. Go where one may, and talk with those who years ago discarded sheep, the usual remark is, "I am going to have a flock," and no wonder, when sheep and lambs sold last spring at the "highest prices since the days of Adam," as one newspaper reporter put it, and at present are making, by far, the easiest money to be got out of any line of farming. Four and a half to five dollars for ordinary lambs to ship in May and June; seven to ten dollars for early-dropped and well-fed ones for the Easter and soon-after markets, cause people to think. Eight dollars and a quarter per 100 pounds quoted in Toronto early last spring for grain-fed ten months' old lambs, with considerably more paid for choice bunches, are prices which compel people to stop and do some calculating. The question now agitating the minds of many farmers is, "Does it pay to run the farm without a flock as well as it would with ten to twenty breeding ewes to raise lambs for the common market?" Or, we have a man say, as we did in Halton County last winter, "Several years ago my farm was clean. I sold my flock. A few years later weeds became troublesome. I bought sheep, and before long weeds were disappearing."

Another gentleman in the same county twenty years ago was a busy man—too busy, he thought, to give any attention to his sheep. The flock returns were disappointing. He decided to turn over the management to his oldest boy, who was getting interested in the stock doings on the farm. The ewes were ordinary long-wool grades. The boy began by securing a ram of one of the Down breeds, continuing all the years since the use of registered rams of the one breed: results, an improvement from the first under the boy's care and management. Regular and very profitable returns were obtained. Last year the best lambs of both sexes were selected out for breeding purposes. The culls, carried along in the fall on the rape field, and after snowfall were fed in addition a little grain, were sold to go to Toronto market in early December, weighing an average of 140 pounds at \$6 per 100, or \$8.40 for each lamb.

Here are facts which furnish food for good solid thinking. Let me add a few more. Last month while travelling in the northern part of Victoria and Peterboro' and all over Haliburton, we made comparisons of the results in dollars secured from the average dairy cow and the growing of stockers in said sections with the raising of lambs for the market. The breeding of all except in one locality was of the outrageous sort. Just a male from the herd or flock selected and turned loose. Allowing the cost of wintering five sheep to equal that of one cow, it was found that the returns in the fall from an average crop of lambs would be \$21 plus five fleeces at \$1.50 each = \$28.50 against \$20 to \$22 for the cow. The lambs did the milking, and there was no time lost or expense

incurred in sending milk to factory or cream to creamery. The cost of 2½ years' old stockers in same sections included two winterings for the steers, the expensive feeding time, and they sold at \$14 to \$22 each. A hundred of them were sold at \$15 for the one at over \$20. The five lambs with no costly wintering, make, in less than five months of cheap summer feeding, more money by *seven and a half dollars* than the average stocker in places mentioned. Need we be surprised in finding that the determination to own a flock is becoming of late as keen as the discarding of sheep was five years ago?

This may be safely laid down as a foundation principle: *there are very few farms in Ontario where sheep cannot be used to add materially to the income*, but good judgment must be exercised to get profitable returns. In selecting ewes for a foundation it is well to secure strong young ewes which promise to be good milkers. Large, strong, sturdy and young ones even at a high price are far more apt to please and be profitable than old or delicately-built ewes at any kind of price. It is well in selecting the ewe to look for large feeding capacity, and aim in finding the ram to mate in which a full, fleshy form is well developed. To get the early-maturing lamb a sire need not be large, but he should not be below medium in size for the breed to which he belongs. Grade ewes of the right kind will give as good returns as if registered, and cost not half as much. On the other hand a registered ram and nothing else should be used. Here is where many have made grievous and costly mistakes, not only in using grade rams, but also what is sometimes worse, *pedigreed scrubs*. Regret it much as we may, the fact remains, that in all breeds and in most of pure-bred flocks, bad mating produces too many inferior rams which are not fit to use in grade flocks, let alone better ones. Unfortunately too many will look at the ten-cent piece so near the eye that they cannot see the dollar a little way off. They will save a few dollars in the purchasing of a ram, and lose ten times as many in the slow-maturing lambs got by him. An active ram will readily sire 40 to 60 lambs each season. The difference of value of one crop of lambs often—quite often—is more than the cost of a good sire. We hear one say, "My ewes are not good enough to justify me in buying a good ram." If not good enough, then by all means get the better ram to make up for the lack in ewes. Poor ewes and a worse ram have little chance to win out against similar ewes and a real good buck to mate them with. A case in mind: One of the best pens of fat wether lambs ever seen at the International Show at Chicago, was shown in a pen adjoining that in which their dams were on exhibition. Good—extra good—as the lambs were, their mothers were the meanest, skinniest and most mongrel-looking western range ewes one could possibly find anywhere. The sire (not on exhibition) was said to be an extra good pure-bred one, hence the goodness of the lambs.

Another consideration in favor of keeping sheep, and a very important one these years with high prices of building materials, is that

winter shelter for sheep need cost but a comparatively small fraction of that required to furnish comfort to other farm stock. Given any shelter, which is dry under foot and over head, with freedom from draughts, and we need not trouble about the cold of winter. Lambing should not be before the middle of April to the first of May. Therefore warm quarters are not required at any time. Lambs dropped late in spring require less care, are usually ready to go right on and grow, as the grass which is then ready, or nearly so, gives the ewes a chance to nurse well. That prevents stunting in early age, and gives a good chance to have heavy, fleshy and fully-developed lambs ready for the market in view. Late lambing allows cheaper winter feeding of the ewe flock. Plenty of good, well-saved pea straw with clover hay and two or three pounds of cut turnips daily to each sheep will bring the flock through the winter successfully. *Fresh water daily* and *the salt box always* are indispensable. Should a ewe fall off in condition, one pound daily of mixed bran and oats is safe and tends to a surer flow of milk at lambing time. Such little attentions prevent disease and troubles of different kinds. In winter an occasional feed of mixed bran and oats, in which two ounces for each sheep of Epsom salts are well mixed, has a tendency to ward off disease. Lambs when a week old should be docked, leaving not more than an inch of the stump. When three weeks old ram lambs should be castrated. Lack of attention to these two details yearly costs our Province thousands upon thousands of dollars.

It is a debatable question whether it is more profitable to wash before shearing or sell the wool in the dirt. Much depends on conditions of convenience, etc. With the present year's discrimination in favor of wool washed before shearing, were it attended to as soon as the weather is warm enough, and there is a good convenient place for washing, there is no doubt but that washing on the sheep's back is more profitable, but there is some danger to men and sheep, also the chance of delay waiting for warm weather. Because of those chances it is a safer rule to shear in the dirt and take the market price for the unwashed article. Soon after shearing it is well, because profitable, to dip all the ewes and lambs so as to destroy ticks, and clean the skin. To insure comfort for the flock in winter a second dipping in the early fall will stop all tendency of the sheep to rub in the pens.

Maggots caused by flies blowing in wet or dirty places near the tail or head is not a common trouble here in summer, yet it is not unknown. A strong solution of McDougall's Dip, or probably of any of the dips, will destroy them. Grub in the head is an ailment prevalent in some localities in the opinion of some. A preventive is said to be found in smearing the nostrils with pine tar occasionally in the early summer months. Sometimes sheep become very lame. Examination reveals an excessive growth of toes and possibly an accumulation of dirt enclosed. A shortening of the toes by the use of the toe clipper soon affords relief. It is a good practice to clip all the older animals' toes at shearing time,

so avoiding all further trouble for the season in that line. Change of pasture field monthly or oftener if possible, with salt and water constantly in reach, is about all the attention required till weaning time. Then a fresh grass field and rape for the lambs and bare pasture for the ewes with several milkings daily for the first and the second or third day afterwards, are the requirements.

We know of nothing that will produce such growth, bloom and fulness of flesh in a bunch of lambs as a supply of well matured rape will during the fall and early winter months. Lambs so fed require but easy feeding in the winter quarters to carry them on for the Christmas market or to a still better market, that of late winter or early spring.

Give daily, in pens, a feed of unthreshed pease in the morning (that were cut when hardly ripe), four pounds to each of cut turnips at noon, clover hay in the evening, and five pounds cut turnips at night, and a steady growth will be maintained. The water and salt must always be in the pens. Then all going well, a handsome advance in value may be counted on, and the net profits doubled or more.

There is no danger of any person getting into trouble in predicting that from now on the sheep is to be returned to its proper place on the farms in Ontario. And why not, when it makes by far more money out of the grass and the weeds and the seeds, the roots, the grains, the hay and anything else fed to it than any other kind of animal we raise, and it does that without our needing to milk or grind for them? All that is required is to give the feed as it comes from the field, only that turnips had better be cut. Does that not tell, and tell materially, when the labor saved is considered, how we can farm, farm well, and cut down expensive labor bills?

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

BREAKFAST FOODS.

THEIR CHEMICAL COMPOSITION, DIGESTIBILITY, AND COST.

BY R. HARCOURT, PROFESSOR OF CHEMISTRY,
AND H. L. FULMER, DEMONSTRATOR IN CHEMISTRY.

INTRODUCTION.

The points specially studied in the present investigation into the nutritive value of breakfast foods are as follows:

1. The chemical composition.
2. The influence of the thoroughness of cooking on the solubility of the organic matter of the raw foods.
3. The digestibility of the organic matter of the cooked and malted foods commonly sold as ready-to-serve, and the extent to which the starch of these foods has been changed to dextrin and maltose.
4. The digestibility of different kinds of breakfast foods, and the influence of short and long cooking on the digestibility of the nutrients of oat and wheat meals.
5. The economic value of the various foods, based on the cost and on the determined composition and digestibility.

THE IMPORTANCE OF CEREAL GRAINS IN OUR DIET.

The cereal grains are prepared for human consumption in a great variety of ways, and form a very important part of our diet. This is doubtless due to the fact that they are grown in almost all parts of the world; that they are cheap foods; that, when properly prepared, they are comparatively easily and completely digested; and that they contain all the constituents required to nourish the body. Moreover, if the findings of the Chittedon School be proven to be correct, they are destined to be even more important, for most of the cereal grains contain abundance of proteids to supply all that these authorities claim is needed to keep the human system in a healthy, vigorous condition.

Some idea of the immense quantities of these foods consumed annually may be conceived when it is pointed out that the world's yearly crop of wheat alone amounts to several billions of bushels, and all or nearly all of this is used as human food. Furthermore, it is estimated that Great Britain uses six bushels of wheat per capita per year; and an American

authority has stated that "Vegetable foods, including flour, breakfast foods, and other cereal products, furnish 55 per cent. of the total food, 39 per cent. of the protein, 8 per cent. of the fat, and 95 per cent. of the carbohydrates of the diet of the ordinary family."* The same authority states that oats, rice, and wheat breakfast foods together furnish about 2 per cent. of the total food, and protein, 1 per cent. of the total fat, and 4 per cent. of the carbohydrates of the ordinary mixed diet. These figures may not appear high, but when we consider the large quantities of food consumed by a family in a year, they represent an immense amount and form a sufficiently important part of our ordinary diet to warrant their careful study.

OUTLINE OF WORK DONE ELSEWHERE.

A large amount of work has been done in various places on this continent in determining the chemical composition and in estimating the comparative value of breakfast foods, and all, or nearly all, of the numerous brands of these foods on the market have been analyzed. Several of the Agricultural Experiment Stations in the United States, principally Storrs, Maine, and Minnesota Stations, have studied the digestibility of these foods. Other Experiment Stations have investigated the influence of the "predigestion" process on the solubility of the organic matter. As the "predigestion" process commonly practised consists almost entirely of the cooking and malting to which the prepared breakfast foods are submitted, and results in bringing starch into solution, it follows that the thoroughness of the preparation processes may be at least approximately estimated by determining the amount of material soluble in water. This knowledge has been utilized by several investigators, particularly at the Wyoming† and Michigan‡ Stations and the Inland Revenue Laboratory, Canada.§ The two latter stations have also made a careful study of the nature of the materials rendered soluble.

The completeness of the digestion of a food is determined by finding out the amount of material absorbed as in the ordinary digestion experiments. Such results, however, give no indication of the ease or rapidity of digestion. Snyder¶ and Gudeman** have investigated the rate of solution or digestion effected by malt, saliva, and pancreatin on breakfast foods cooked for different lengths of time.

THE NATURE OF BREAKFAST FOODS ON THE MARKET.

The origin of the present numerous varieties of breakfast foods may be traced back to the "porridge" made by simply boiling coarsely ground

*U. S. Department of Agriculture, Farmers' Bulletin No. 249.

†Wyoming Station Bulletin No. 33.

‡Michigan Agricultural College Experiment Station Bulletin 211.

§Laboratory of the Inland Revenue Department Bulletins Nos. 84, 127, and 132.

¶Minnesota Experiment Station Bulletin No. 74, p. 153.

**Journal American Chemical Society, Vol. 26, p. 321.

1a Bu'l. 162.

wheat or oats. These materials, while fairly satisfactory to persons of robust health, doing outdoor labor, were often found to so irritate the intestines as to cause increased peristaltic action. This may be an advantage to persons doing sedentary work, but it may be a positive injury to others. With the development of machinery capable of removing the coarse branny parts of the grain, this fault has been largely overcome. More recently there has been a demand for more tasty food of a nature that may be quickly prepared for the table, and a great variety of breakfast cereals of the ready-to-serve type have been placed on the market. These products are, in general, attractive and palatable, and afford a pleasing variety in the diet; and because of special treatment in the process of manufacture, the amount of labor entailed in their preparation for the table is materially reduced. This is doubtless one reason why they have become so popular; but, on the other hand, no class of foods has been so extensively advertised; and such an endless variety of wonderful virtues have been claimed for them that people were led out of curiosity to try them. Some of the breakfast foods are stated to contain several times as much nourishment as the same weight of beef; others are lauded as especially valuable as brain food, or nerve tonics, and very many are claimed to be particularly well suited for persons of weak digestion. There may be some truth in the last statement, but it is evident that many of the claims are utterly groundless. Yet these very fanciful statements have served the purpose of attracting attention, and have, without a doubt, increased the sales of these foods.

The grains commonly used in preparing the breakfast foods in this country are oats, wheat, and corn, and, to some extent, barley and rice. The foods prepared from these may be roughly divided into four classes: (first) the uncooked, (second) the partially cooked, (third) the cooked, and (fourth) the malted and cooked foods.

First. The Uncooked. In the first class we have the granulated forms of oatmeal, the wheat farinas, cornmeal, and rice. The oatmeals are of three grades. The best grade is that known as granulated or pin head. In preparing it the kiln-dried and hulled grain is cut with cutters and the fine meal, or low grade materials, taken from it. The second grade, known as the standard or mid-cut, is prepared by a gradual reduction of the oat kernels by cutters and grinders and more of the germ of the grain is left in the food. What is called coarse cut, or the third grade, is the whole meal prepared without gradual reduction. In every case the grain is kiln-dried. This makes the grain more brittle, and gives it the desired flavor.

The wheat farinas are sold under a great variety of names, as Cream of Wheat, Meat of Wheat, Wheat Crystals, etc. They are usually prepared from the hard granulated particles of the wheat got from the first and second breaks in the manufacture of flour—the part of the wheat from which the patent flour is made. As the soft winter wheats tend to break down too fine, the hard spring wheats are ordinarily

used in the preparation of this class of breakfast foods. Frequently they are "fired" as a last step in their manufacture, to increase the flavor and improve the keeping quality.

Corn bread of various kinds and corn mush are used quite extensively throughout this Province; although in the latter form it does not appear to be so popular as it was formerly. The germ of the corn is relatively large and rich in fat, and flattens out in the grinding, and, therefore, is readily removed when the meal is bolted. As the germ is taken out of most of the finer grades, the corn meal on the market usually contains no more fat than wheat meals. The removal of the germ improves the keeping quality of the corn meal, because the fat tends to become rancid.

Second. The Partially Cooked. These comprise the rolled oats and flaked grains. In preparing the rolled oats, the grain is kiln-dried, either by direct heat or by steam under pressure, hulled, steamed, and rolled. The preliminary treatment of cleaning, kiln-drying, and hulling, is practically the same whether the oats are made into granulated or the rolled forms. The flaked oats are prepared very much in the same way as the rolled oats, but the ends of the grains are broken off and are placed in a lower grade of the meal. A certain amount of fine white dust is also separated and sold as a by-product. Possibly only about 35 to 50 per cent. of the whole grain remains as the flaked product.

Nearly all the grains, including rice, peas, and beans, can now be procured in flaked form. Recently a new form of barley breakfast food has appeared on the market. It differs from the ordinary flaked barley in that in the preparation the grain is first sprouted and then dried, steamed, and rolled. Certain definite changes take place during the sprouting which should render the product more easily digested. As all the rolled and flaked grains, unless roasted or parched after flaking, are only partially cooked, they require thorough cooking before serving.

Third. The Cooked. The class of foods which would naturally fall under our third class are the Shredded Wheat Biscuit, Toasted Corn Flakes, Puffed Wheat Berries, etc. The Shredded Wheat Biscuits are made by softening the wheat, drawing it out into shreds and piling these upon one another until high enough for the desired purpose and then cooked by dry heat. In some cases, as with Toasted Corn Flakes, the raw grain is flaked and then cooked by parching or toasting, or again the raw grains are moistened with water or other liquid, then cooked by roasting, and finally, crushed. Nearly all of these toasted or parched preparations, either shredded or flaked, are sufficiently cooked to be eaten without further cooking.

Fourth. Malted and Cooked. The fourth class of breakfast foods includes those which are both cooked and malted. The cereal grains are rich in starch, which, because of the hard, impervious nature of the walls of the granules of starch, is practically indigestible in the raw state. Cooking ruptures these cell walls and the contents are then comparatively readily acted upon by the digestive juices. The object of treating these

starchy foods with malt is to still further reduce the labor of digestion. Malt contains an enzyme called diastase, which has the power of rapidly liquefying the starch after the cell walls are ruptured and of then converting it into dextrin and maltose. The latter substance is a sugar and the former is a somewhat similar compound found in large quantities in the crust of bread and in toast where it has been formed by the action of the high heat to which bread has been submitted and to which the sweetness of these materials is usually attributed. Both of these compounds are very soluble and several steps nearer the completion of the digestive process. Naturally the amount of starch changed into these soluble compounds will depend upon the thoroughness with which the malting process has been carried out. Some investigations we have made on this point indicate that the material rendered soluble varies from 17 per cent. to over 44 per cent. of the dry matter of the food.

It is extremely doubtful if the treatment of cereals with malt materially increases their nutritive value. Persons with weak digestion may find them helpful, but it is hard to understand how this treatment will increase the value of the food to such an extent as is sometimes claimed in advertising matter. They may be more easily digested, but digestion experiments show that they are no more fully digested and absorbed than are the older forms of breakfast foods when properly cooked.

This last class of foods is practically always sold in air-tight paper and cardboard packages, which serve to exclude the dust and dirt that sometimes get into the bin or barrel in which the goods sold in bulk are kept. The neat appearance of these packages, and the appetizing nature of the goods, together with the extensive advertising they have received, have forced the manufacturers of other lines of breakfast foods to be more careful of the quality of their products and to pay more attention to the condition in which they are put upon the market. This has resulted in improvements being made in the machinery for cleaning grain and, in some instances, to greater cleanliness around the mill. Altogether we are safe in concluding that the breakfast foods offered for sale to-day are more carefully prepared and handled than they were in former years.

COMPOSITION OF BREAKFAST FOODS.

To intelligently estimate the nutritive value of any of these foods, several factors must be considered. The most important of these are, the chemical composition, the digestibility, the palatability, and the cost.

In the present investigation, the composition of the foods was ascertained by analyzing samples collected partly from the manufacturer and partly from the retail dealer. The analyses were made according to the methods proposed by the Association of Official Agricultural Chemists, and the results are recorded in Table No. 1.

Before we present the results of the analyses, however, let us review the meaning of the terms used by chemists to designate the various components of a food.

Moisture. Every one of the foods under discussion, no matter how dry it may appear, contains some water which can be driven out by heat. A high water content is not desirable, because it not only diminishes the percentage of actual food material, but it also tends to cause the food to mould or turn sour. Water has certain physiological functions to perform in the body, but it may be supplied from so many sources that it has no particular value as a food.

Protein is the name commonly given to a class of substances which furnish the materials for the formation of bone, flesh, blood, etc. This constituent is absolutely essential in the food of animals; for, without it, no animal can grow or even subsist. Moreover, the animal is totally unable to create protein; that is a function of plant life. The animal can simply appropriate and transform the protein of plants into the particular proteids of the body. Protein, when oxidized or burned in the body, will produce heat, and if eaten in excess of that required for other purposes, may form fat. Altogether protein is one of the most important constituents of a food, and the one which is the most expensive. Hence we naturally like to find a food rich in this substance.

Fat, or ether extract, is that part of the food which may be extracted from the water-free material by ether, benzine, gasoline, etc. It is of value for the formation of fat in the body and for the production of energy and heat. For this latter purpose it has more than twice the value of protein and carbohydrates. Fat may, therefore, be looked upon as a concentrated heat producer.

The Soluble Carbohydrates, or nitrogen-free extract, consist mainly of starches, sugars, and closely allied compounds. In the cereal breakfast foods these soluble carbohydrates form about two-thirds of the whole material. Their particular function in the body is to form fat, or, when oxidized, to produce heat and energy. They are frequently called the energy or heat producers.

Crude Fibre is the term applied to a group of substances which form the woody or straw-like frame-work of plants. It is so indigestible that it has almost no food value, and, further, it frequently renders the rest of the food less digestible by protecting it from the action of the digestive fluids. Therefore, a large amount of it in a food is not desired. Yet, it is undoubtedly physiologically useful in giving the needed bulk to the food.

Ash is the inorganic or mineral part of foods. It is of great importance in the food of the young, as it furnishes the phosphates, chlorides, and other salts of calcium, magnesium, sodium, potassium, iron, etc., which are needed in building up bone and the tissues of the body.

Heat of Combustion. The various nutrients above referred to when supplied in the food enable the body to grow and to repair its tissues as they are worn out in the necessary exercise of the body functions. They also supply the body with the energy needed for doing work both internal and external, and furnish the heat to keep the body warm. All the nutrients, except the ash, may be oxidized or burned in the body, and are

therefore, sources of energy. Consequently, the total energy value of a food may be determined by measuring the amount of heat given off when a definite weight of the food is burned. This energy value is conveniently stated in terms of heat, the Calorie,* or unit of heat, being used for this purpose. The number of Calories of heat a gram of each food is capable of producing, if fully burned, is given in the last column of Table No. 1. As it was not convenient for us to determine the actual fuel values, the figures were obtained by calculating them on the basis proposed by Dr. H. W. Wiley.†

It is very difficult to form a correct comparative estimate of the nutritive value of the breakfast foods from the percentage composition alone. For this reason we sometimes value the foods on the basis of their ability to produce heat, and, if we assume that they are fed in a properly arranged diet, the fuel values indicate fairly well the comparative nutritive values of the total food.

With the foregoing facts in mind regarding the value of the different nutrients, we now turn to the table of composition :

TABLE NO. 1—PERCENTAGE COMPOSITION OF SOME BREAKFAST FOODS.

Sample Number.	Foods and Manufacturers.	Water.	Crude Protein.	Crude Fat.	Nitrogen Free Extract.	Crude Fibre.	Ash.	Heat of Combustion per gram Calories.
OAT PRODUCTS								
<i>Granulated Oatmeal from:</i>								
10	D. R. Ross, Embro.....	7.31	13.31	6.30	69.16	2.42	1.50	4.306
14	Martin Bros., Mount Forest...	7.51	12.43	6.31	70.29	1.94	1.52	4.282
40	Martin Bros., Mount Forest...	7.56	12.77	6.31	70.22	1.49	1.65	4.277
18	Am. Cereal Co., Peterboro..	9.16	12.26	7.26	68.53	1.32	1.47	4.262
27	Flavelle Milling Co., Lindsay.	7.68	12.62	6.29	70.68	1.36	1.37	4.283
<i>Standard Oatmeal from:</i>								
35	Martin Bros., Mount Forest...	7.35	13.17	7.53	69.19	1.04	1.72	4.412
39	Martin Bros., Mount Forest...	7.84	13.44	6.95	68.36	1.56	1.85	4.306
24	Am. Cereal Co., Peterboro..	8.53	13.30	6.49	68.61	1.63	1.41	4.268
20	D. & S. Am. Cereal Co., Peterboro.....	9.33	12.80	7.40	67.98	1.45	1.40	4.257
13	D. R. Ross, Embro.....	7.95	15.28	5.77	66.69	2.01	2.30	4.254
28	Flavelle Milling Co., Lindsay.	6.71	12.21	7.61	70.62	1.16	1.68	4.371

*A Calorie represents the amount of heat required to raise the temperature of 1,000 grams of water 1° C.

†Bulletin No. 13, part 9, Bureau of Chemistry, Department of Agriculture, U.S.A.

TABLE No. 1: PERCENTAGE COMPOSITION OF SOME BREAKFAST FOODS.—*Continued.*

Sample Number.	Foods and Manufacturers.	Water.	Crude Protein.	Crude Fat.	Nitrogen Free Extract.	Crude Fibre.	Ash.	Heat of Combustion per gram Calories.
	<i>Coarse Cut Oatmeal from;</i>							
26	Martin Bros., Mount Forest...	8.15	12.77	6.01	69.65	1.80	1.62	4.242
	<i>Rolled Oatmeal from:</i>							
2	Galt Milling Co., Galt... ..	9.42	12.45	7.30	68.10	1.06	1.67	4.249
3	W. Thomson & Son, London..	9.59	12.28	6.52	68.83	1.18	1.80	4.141
25	W. Thomson & Son, London..	8.68	12.29	5.99	70.16	1.39	1.49	4.216
4	Tillson Co., Tillsonburg.....	8.04	14.39	7.24	67.37	1.08	1.88	4.746
51	" " " " " "	9.47	11.29	6.41	69.82	1.35	1.66	4.180
52	" " " " " "	9.00	11.81	5.96	70.20	1.39	1.64	4.187
53	" " " " " "	9.36	11.84	5.68	69.94	1.30	1.88	4.148
54	" " " " " "	8.41	12.23	6.69	69.70	1.35	1.62	4.257
44	" " " " " "	7.45	12.21	7.27	70.22	1.15	1.70	4.323
7	Woodstock Cereal Co., Woodstock.....	8.50	13.12	4.14	71.72	0.80	1.72	4.221
11	D. R. Ross, Embro.....	9.52	13.11	5.94	68.61	1.30	1.51	4.192
17	P. McIntosh & Son, Toronto..	9.11	11.69	6.82	69.20	1.53	1.65	4.224
23	American Cereal Co., Peterboro	9.70	13.30	6.80	67.23	1.42	1.55	4.232
42	" " " " " "	8.12	13.25	7.28	68.45	1.12	1.78	4.321
55	" " " " " "	8.71	12.26	7.98	67.92	1.55	1.58	4.401
56	" " " " " "	8.56	12.21	7.76	68.51	1.42	1.54	4.309
29	Flavelle Milling Co., Lindsay.	6.20	11.57	7.68	71.96	1.25	1.34	4.396
31	Martin Bros., Mount Forest...	7.93	12.09	7.47	69.72	1.11	1.68	4.312
32	Ground Oatmeal, Galt Milling Co.....	8.60	12.43	6.10	69.30	1.31	2.25	4.196
	WHEAT PRODUCTS.							
1	Wheatine, Milne Bros., Markham.....	10.90	11.91	2.00	72.33	1.37	1.49	3.910
6	Steven's Breakfast Food, Canada Flour Mills Co., Chatham.....	11.38	9.18	0.83	77.20	0.58	0.83	3.800
38	Steven's Breakfast Food, Canada Flour Mills Co., Chatham.....	10.58	9.18	1.10	78.24	0.36	0.54	3.877
8	Farina, Goldie Milling Co., Ayr.....	12.13	9.01	0.61	77.05	0.55	0.65	3.670
45	Farina, Goldie Milling Co., Guelph.....	10.55	9.70	1.36	77.53	0.44	0.42	3.896
36	Wheat Germ, Goldie Milling Co., Guelph.....	8.39	10.97	2.79	75.61	1.16	1.08	4.073
33	Wheat Crystals, Hedley, Shaw Milling Co., Toronto.....	9.57	11.53	1.36	76.34	0.44	0.76	3.955
49	Meat of Wheat, Western Cereal Co., Winnipeg.	10.60	9.17	1.40	78.46	.....	0.37	3.888
50	Cream of Wheat, Cream of Wheat Co., Minneapolis..	11.04	9.14	0.43	78.93	.....	0.46	3.815

TABLE NO. 1: PERCENTAGE COMPOSITION OF SOME BREAKFAST FOODS.—*Continued.*

Sample Number.	Foods and Manufacturers.	Water.	Crude Protein.	Crude Fat.	Nitrogen Free Extract.	Crude Fibre.	Ash.	Heat of Combustion per gram Calories.
<i>Rolled Wheat:</i>								
86	Swiss Food, P. McIntosh & Son	12.10	9.63	0.86	73.65	1.88	1.88	3.745
87	Pettijohn Breakfast Food, American Cereal Co., Chicago	11.66	9.63	0.65	74.54	1.98	1.54	3.766
5	Rolled Wheat, Tillson Co., Tillsonburg	10.96	8.16	1.83	75.14	1.71	1.75	3.829
41	Rolled Wheat, Tillson Co., Tillsonburg	9.19	9.81	2.27	76.15	1.07	1.51	3.956
22	Rolled Wheat, Robt. Greig Co., Toronto	9.86	8.94	1.97	75.19	2.39	1.65	3.893
BARLEY PRODUCTS.								
16	Cracked Barley, Tillson Co., Tillsonburg	9.49	9.23	0.84	77.72	1.34	1.38	3.864
46	Flaked Barley, Tillson Co....	10.18	10.62	1.21	75.62	1.27	1.10	3.892
47	Flaked Barley, Robt. Greig Co., Toronto	9.79	8.87	1.24	78.45	0.77	0.88	3.887
21	Flaked Barley, Robt. Greig Co., Toronto	12.76	9.34	0.88	75.34	0.98	0.70	3.762
CORN PRODUCTS.								
30	Corn Meal, Tillson Co., Tillsonburg	10.00	7.11	1.88	79.72	0.58	0.71	3.887
37	Corn Meal, Tillson Co., Tillsonburg	9.52	6.87	0.65	82.21	0.46	0.29	3.855
83	Corn Meal, Tillson Co., Tillsonburg	10.18	5.70	1.22	81.93	0.54	0.43	3.831
19	Rice Flakes, Robt. Greig Co., Toronto	12.29	7.24	0.08	79.49	0.55	0.35	3.716
READY TO SERVE PRODUCTS.								
9	Orange Meat, Sample 1, Frontenac Cereal Co., Kingston	8.36	8.66	1.12	77.89	1.95	2.02	3.887
59	Orange Meat, Sample 2....	7.63	9.19	1.33	79.97	.....	1.88	3.945
60	" " " 3.....	10.31	10.81	1.51	75.52	.....	1.85	3.875
34	Canada Flakes, Sample 1, Peterboro Cereal Co., Peterboro.....	7.49	9.42	1.65	76.53	2.21	2.70	3.938
61	Canada Flakes, Sample 2....	8.81	10.81	1.36	75.99	.....	1.36	3.880
	" " " 3.....	9.16	11.06	1.00	76.23	.....	2.55	3.871
43	Force, Sample 1, The "Force" Food Co., Buffalo, N. Y....	7.37	9.81	2.13	76.45	1.85	2.40	3.987
63	Force, Sample 2.....	9.93	10.88	1.00	75.62	.....	2.57	3.835
64	" " " 3.....	9.92	9.65	1.40	76.76	.....	2.27	3.847

TABLE NO. 1—PERCENTAGE COMPOSITION OF SOME BREAKFAST FOODS.—*Concluded.*

Sample Number.	Foods and Manufacturers.	Water.	Crude Protein.	Crude Fat.	Nitrogen Free Extract.	Crude Fibre.	Ash.	Heat of Combustion per gram Calories.
	READY TO SERVE PRODUCTS— <i>Con.</i>							
48	Norka, Norka Food Co., Battle Creek, U.S.	7.10	13.57	4.83	69.70	1.84	2.96	4.183
65	Norka, Sample 2.....	7.18	14.88	6.03	69.19	.....	2.72	4.276
66	" " 3.....	7.86	14.75	5.78	68.87	.....	2.74	4.232
57	Malta Vita, Sample 1, Pure Food Co., Battle Creek...	8.79	8.78	0.92	79.30	.....	2.21	3.855
67	Malta Vita, Sample 2.....	7.70	10.88	1.63	77.42	.....	2.37	3.968
68	" " 3.....	8.24	10.06	1.54	78.03	.....	2.13	3.937
58	Grape Nuts, Postum Cereal Co., Battle Creek, U.S....	5.68	9.49	0.64	82.50	.....	1.69	4.002
69	Grape Nuts, Sample 2.....	7.47	12.37	1.50	76.89	.....	1.77	4.022
70	" " 3.....	8.10	12.63	0.70	76.89	.....	1.68	3.963
71	Shredded Wheat, Sample 1, Canadian Shredded Wheat Co., Niagara Falls.....	9.54	12.00	1.06	75.76	.....	1.64	3.913
72	Shredded Wheat, Sample 2...	9.28	10.81	0.64	75.50	.....	1.77	3.874
74	Quaker Wheat Berries, American Cereal Co., Chicago, Sample 1.....	9.15	11.05	2.00	73.03	3.33	1.44	3.969
75	Quaker Wheat Berries, sample 2	8.99	11.23	2.21	72.67	3.46	1.44	3.989
76	" " 3	8.98	11.51	2.56	72.56	2.96	1.43	4.014
77	" " 4	8.96	12.26	2.58	71.33	3.55	1.32	4.033
78	Toasted Corn Flakes, Battle Creek Health Food Co., London, Ont., Sample 1..	9.85	5.35	2.69	79.57	0.64	1.90	3.855
79	Toasted Corn Flakes, Sample 2	9.81	5.42	1.05	81.97	0.64	1.11	3.805
80	" " 3	9.75	5.19	1.11	81.32	0.64	1.99	3.800
81	" " 4	9.65	6.21	1.11	80.24	0.66	2.13	3.787
82	Quaker Puffed Rice, American Cereal Co., Chicago.....	10.16	5.20	0.33	83.25	0.70	0.36	3.887
84	Life Chips, Battle Creek Health Food Co., London.....	8.68	6.78	2.11	77.96	1.99	2.48	3.874
85	Gusto, The Hoco Mills Co., Buffalo, N.Y.	11.20	7.18	0.24	77.24	1.51	2.63	3.675
88	Granose Flakes, Battle Creek Health Food Co., London	9.96	8.32	0.32	77.30	1.99	2.11	3.772
89	Granose Biscuit, Battle Creek Health Food Co., London	12.31	8.04	0.71	73.65	1.95	3.34	3.640
90	Malt Breakfast Food, The Malted Cereals Co., Burlington, Vt.....	10.05	11.80	0.46	75.37	1.17	1.20	3.875

Properly matured grain of the same species and variety is fairly constant in composition, but different varieties of grain, or the same variety grown in different sections of the country, or in different years,

will vary slightly. One of the objects of giving the results of the analysis of the individual samples is to show this variation. It is evident that the method of preparing the various kinds of oatmeals has not materially affected the composition, for there is a general similarity in the percentages of protein, fat, etc., and even in crude fibre, in all forms of these foods. The differences in the composition are most evident in the protein column, and these must be due largely to the differences in the original grain.

With reference to the wheat products, it is obvious that the different names given to the various foods by the manufacturer are not associated with wide differences in chemical composition. When these foods are composed of the granular particles from the first and second breaks in the regular flour milling process, a portion of the bran layers will naturally be excluded, and the resulting product will not contain so much crude fibre and ash as the whole grain. This, it will be noticed, is the case with the farinas, such as Wheat Crystals, Meat of Wheat, and Cream of Wheat. Wheatine and the rolled wheats more nearly resemble the composition of the whole grain.

Judging by the similarity of the composition of the cracked and flaked barley, it is evident that the latter is practically the whole hulled grain.

For reasons previously stated, the germ is removed in preparing the finer grades of cornmeal. Consequently, while the whole corn kernel contains about five per cent. of fat, the cornmeals analyzed have less than two. The comparatively wide variation in the amount of this constituent is probably due to differences in the amount of the germ left in the meal. This food is also characterized by its low crude fibre and high nitrogen free extract content.

The composition of the different samples of the same kind of the ready-to-serve foods is fairly uniform, but, naturally, the foods are subject to the same variations in this respect as the grains from which they are prepared. Thus Norka is an oat product, and, consequently it is richer in both proteids and fat than the preparations made from wheat and corn. The latter substances, as represented by Toasted Corn Flakes, are particularly low in proteids and crude fibre.

To bring out more clearly the differences in composition of the various kinds of foods analyzed, the results have been averaged, and they are given in Table No. 2. For purposes of comparison the composition of a few of the more common foods that occur in our daily diet are also given.

In general, it may be pointed out that the oatmeals and Norka contain the most protein and fat, while all the other foods are richer in carbohydrates. The cornmeals are the lowest in protein and the highest in carbohydrates, and wheat farinas and cornmeal contain the least fibre. The germ of a seed is rich in protein and fat, consequently, we are not surprised to find the wheat germ richer in these constituents than the other wheat products. The malted foods are not richer in the valuable

TABLE NO. 2: TABLE OF AVERAGE COMPOSITION.

Product.	No. of samples analysed.	Water.	Crude Protein.	Crude Fat.	Nitrogen free extract.	Crude Fibre.	Ash.	Heat of Combustion per gm. Calorie.
Granulated Oatmeal.....	5	7.84	12.68	6.49	69.78	1.71	1.50	4.283
Standard Oatmeal.....	6	7.95	13.37	6.90	68.57	1.48	1.73	4.276
Coarse Cut Oatmeal.....	1	8.15	12.77	6.01	69.65	1.80	1.62	4.242
Rolled Oatmeal.....	18	8.60	12.41	6.72	69.36	1.26	1.65	4.253
Wheat Farinas.....	7	10.84	9.56	1.01	77.54	.47	.58	3.856
Wheat Germ.....	1	8.39	10.97	2.79	75.61	1.16	1.08	4.073
Rolled Wheat.....	5	10.79	9.25	1.51	74.94	1.80	1.71	3.832
Flaked Barley.....	3	10.91	9.61	1.11	76.47	1.01	.89	3.847
Corn Meal.....	3	9.90	6.56	1.25	81.28	.53	.48	3.857
Malt Breakfast Food.,.....	1	10.05	11.80	.46	75.32	1.17	1.20	3.875
Orange Meat.....	3	8.77	9.55	1.32	76.49	1.95	1.92	3.903
Canada Flakes.....	3	8.49	10.43	1.34	75.33	2.21	2.20	3.919
Force.....	3	9.07	10.11	1.51	75.05	1.85	2.41	3.890
Norka.....	3	7.38	14.40	5.55	68.02	1.84	2.81	4.230
Malta Vita.....	3	8.24	9.91	1.36	*78.25	.....	2.24	3.919
Grape Nuts.....	3	7.08	11.50	.95	*78.76	.....	1.71	3.996
Shredded Wheat.....	2	9.41	11.41	.85	*76.62	.....	1.71	3.894
Quaker Wheat Berries.....	4	9.02	11.51	2.34	72.39	3.33	1.41	3.991
Toasted Corn Flakes.....	4	9.77	5.52	1.49	80.79	.65	1.78	3.803
Quaker Puffed Rice.....	1	10.16	5.20	.33	83.25	.70	.36	3.887
Rice Flakes.....	1	12.29	7.24	.08	79.49	.55	.35	3.716
Life Chips.....	1	8.68	6.78	2.11	77.96	1.99	2.48	3.874
Gusto.....	1	11.20	7.18	.24	77.24	1.51	2.63	3.675
Granose Flakes.....	1	9.96	8.32	.32	77.30	1.99	2.11	3.772
Granose Biscuits.....	1	12.31	8.04	.71	73.65	1.95	3.34	3.640
<i>Miscellaneous Foods for Comparison.</i>								
Flakes Peas.....	1	8.06	23.39	1.74	63.18	.70	2.13	3.716
White Bread†.....	4	40.06	8.49	1.87	48.73	.....	.85	2.673
Entire Wheat Bread†.....	3	45.41	7.79	2.27	43.47	.....	1.06	2.453
Graham Bread†.....	2	45.00	8.02	2.49	43.00	.....	1.49	2.468
Sirloin Steak†.....	.....	61.9	18.9	18.5	.....	.....	1.00	2.836
Whole Egg, edible portion†.....	.....	73.7	18.9	10.5	.....	.....	1.00	1.767
Cheese, as purchased†.....	.....	34.2	25.9	33.7	2.4	.....	3.80	4.761
Milk§.....	5,000	87.1	3.2	3.9	5.1	.....	.70	.751
Potatoes.....	81	78.41	2.18	0.1	17.82	.60	.89	.893

* Includes crude fibre.

† U.S. Department of Agriculture, Office of Experiment Stations, Bull. No. 148, p. 14. Averages of analyses of bread made from flour samples Nos. 6133, 6142 and 6155.

‡ U.S. Department of Agriculture, Farmers' Bulletin No. 128, p. 12.

§ "Modern Methods of Testing Milk and Milk Products," Van Slyke, p. 15.

nutrients than the other foods, and, so far as we may judge from their mere chemical composition, are not superior in value. Taking all the facts into consideration, we would naturally be led to conclude that, as the oat products contain the most protein, or muscle-forming material, and the largest percentage of fat, they are the most nutritious foods. It is also evident that these foods are also superior to all others as heat producers.

INFLUENCE OF SPECIAL PROCESS OF MANUFACTURE ON SOLUBILITY OF FOODS.

The composition, as given above, does not show the changes that cooking, parching and malting processes have effected in the ready-to-serve foods, and, as it is because of these changes that so much is claimed for them, we studied this point somewhat fully. The object of treating these foods with malt is to increase the solubility, and, consequently, the ease of digestion of the starch. As previously explained, the diastase of malt converts starch into dextrin and maltose,—water-soluble compounds. Cooking in water, or by dry heat, as in toasting or parching, also tends to break down starch into simpler substances which are soluble in water. If, then, we determine the amount of a food that will dissolve in water, we must, to some extent, measure the efficiency of the malting and cooking processes used in the preparation of that food. In order that we might procure some data on this point, we determined the amount of the total solids soluble in water in some uncooked, partially cooked, cooked, and cooked and malted foods. We also analyzed the water extract to ascertain how far the decomposition process had proceeded.

The methods used in making the extractions and determinations were based on those outlined by A. McGill in Bulletin No. 84, Inland Revenue Department, Ottawa. Briefly, the methods were as follows. 100 grams of the material in its natural condition and 1,000 cc. of distilled water at room temperature were placed in a 2-litre bottle, and fastened on a rotating machine which turned the bottles end over end at the rate of 40 revolutions per minute for 24 hours. Previous experimental work demonstrated that up to this length of time there was a sensible increase in the amount of material brought into solution. The contents of the bottle were then placed in a cup of 300 cc. capacity in a large centrifuge and whirled at the rate of 2,000 revolutions per minute for one hour, or until the insoluble matter was thrown down. After filtering through close paper, to insure a clear solution, the per cent. of solids, dextrin, sugar, and proteids were determined. The dextrin was estimated by evaporating a portion of the clear filtrate nearly to dryness, and afterwards taking up with alcohol, filtering off, drying, and weighing the resulting precipitate. As such a precipitate would not be pure dextrin, it is reported simply as "alcohol precipitate." The sugar was determined in the usual way with Fehling's solution, and, as no effort was made to separate the probable sugars present, it was reported as "cuprous oxide precipitate." Approximately, 1 per cent. of cuprous oxide is equal to

.542 per cent. of dextrose or grape sugar, or .81 per cent. of maltose. As generally carried out, the malting and cooking processes will not decompose starch into compounds simpler than maltose, and if dextrose is present, it may, under ordinary conditions, be looked upon as an added product. The amount of nitrogen was obtained by the Kjeldahl method and multiplied by the factor 5.7 to convert to protein. It is obvious that the results may not indicate the amount of the several constituents present in a soluble form in the food as purchased, but they do show the amount that is brought into solution under a similar method of treatment and may be used for purposes of comparison. The results obtained are embodied in the following table :

TABLE NO. 3; PERCENTAGE OF WATER SOLUBLE MATERIALS IN FOODS EXAMINED.

Food.	No. of samples analysed.	Total solids.	Alcohol ppt. (dextrin).	Cuprous oxide ppt. (sugar).	Soluble Proteids.
<i>Uncooked Foods.</i>					
Wheat Farinas	13	6.60	.97	1.18	2.42
Wheat Germ.....	2	7.06	2.45	3.03	1.93
Granulated Oatmeals	4	6.55	*	none.	*
<i>Partially Cooked Foods.</i>					
Rolled Oats	19	6.68	2.53	none.	.74
Swiss Food (rolled wheat)....	1	5.95	*	*	*
<i>Cooked Foods.</i>					
Shredded Wheat	7	13.71	8.26	2.03	*
Quaker Wheat Berries	4	27.00	22.58	3.47	2.28
Toasted Corn Flakes.....	4	28.3	19.63	5.77	.32
Quaker Puffed Rice.....	1	41.61	41.82	2.11	1.34
<i>Malted Foods.</i>					
Malt Breakfast Food.....	1	14.77	.66	10.63	.86
<i>Malted and Cooked Foods.</i>					
Orange Meat	2	23.65	†8.66	†7.43	*
Grape Nuts	5	44.20	12.96	21.02	1.73
Malta Vita	5	25.45	9.97	8.01	1.33
Canada Flakes	3	28.60	†10.16	†12.53	*
Force	7	17.08	9.16	2.73	*
Life Chips	1	18.92	9.84	2.53	.86
Gusto	1	25.14	8.14	2.01	.53
Norka	1	28.17	12.42	10.89	*

* No determination made.

† One result only.

The above figures clearly show that there are wide differences in the solubility of the dry matter and in the quantity of alcohol precipitate (dextrin) and reducing substances (sugars) in the foods examined. The percentage amount of the solids of the farinas, wheat germ, and granulated oatmeals dissolved is about equal, while the partial cooking to which the rolled oats and wheat were incidentally subjected in the process of manufacture, has not been sufficient to materially increase the solubility of these foods. Or, if, as some contend, diastase is present in very small quantities in raw grain, possibly the solubility of the uncooked foods has been influenced by enzymic action.

Among the foods sold as being cooked sufficiently to be ready to serve, it will be observed that there are wide differences in the per cent. of solids soluble in water. This indicates that some were much more thoroughly cooked than others. It is also evident that the cooking has not resulted in the formation of any appreciable amount of sugar. The Malt Breakfast Food, which was malted but not cooked, shows a considerable amount of sugar, showing that the process was continued far enough to cause a large portion of the solids to pass through the dextrin into the sugar. It is, of course, possible, that sugar was added, but no effort was made to ascertain this point. It may be stated, however, that there was evidence that the food was really malted.

Among the malted and cooked foods there are also wide differences in the percentage amount of soluble matter. It must be remembered that the amount of malt used and the length of time it is allowed to act must influence the quantity of the starch rendered soluble and also the amount of sugar formed. Some of these foods do not contain as much soluble matter as the foods that were cooked only. The same foods have no more, or very little more, sugar than the uncooked foods, which would indicate that very little change due to malting had really taken place. Certainly there is very little to show that some of these foods have been any more than cooked, and, it will be shown later, that the cooking, as measured by the solubility of the carbohydrates, has not been as thorough as is commonly practiced in preparing the ordinary farinas and oatmeals for the table. Further, it is apparent that the predigestion has not affected the solubility of the proteids, for the water extract of these malted or "predigested" foods contains no more of these valuable food constituents than that obtained from the cooked foods. This is as expected, for the malting process can affect the carbohydrates only and has no influence on the other constituents of the food.

It is quite conceivable that in the preparation of different lots of the same brand of food, the manufacturer may consciously or unconsciously have allowed the malting process to proceed further with some than with others, or the cooking may have been more thorough. Any such differences in treatment would cause variation in solubility between the different lots or batches, so that one package of a food may not be as soluble

or as readily digested as another. In some cases these variations were so wide as to seriously affect the value of the food. The following table, which contains the individual results obtained from some of the foods, is given to show these variations:

TABLE NO. 4: PERCENTAGE OF WATER SOLUBLE MATERIAL IN DIFFERENT SAMPLES OF THE SAME BRAND OF FOODS.

Food.	Total Solids.	Alcohol ppt. (dextrin).	Cuprous oxide ppt. (sugar).	Soluble proteids.
<i>Uncooked Foods.</i>				
1. Farina.....	5.08	1.94	1.11	*
2. Cream of Wheat.....	4.83	1.95	.88	1.69
3. " ".....	5.04	1.80	1.43	1.83
4. Goldie's Farina.....	5.65	1.76	.90	2.98
5. Steven's Breakfast Food.....	6.84	1.36	2.12	2.23
6. " " ".....	5.97	1.28	1.44	2.26
<i>Partially Cooked Food.</i>				
1. Tillson's Oatmeal.....	8.43	2.36	none.	*
2. " ".....	7.8	3.03	"	.67
3. " ".....	6.7	1.68	"	1.15
4. " ".....	8.0	2.99	"	1.21
5. " ".....	10.10	4.20	"	.65
6. " ".....	6.28	3.16	"	.58
7. " ".....	7.04	3.99	"	*
8. " ".....	9.09	3.45	"	.86
9. " ".....	7.27	4.58	"	.87
1. Quaker Oats.....	5.42	*	"	*
2. " ".....	5.20	.80	"	.76
3. " ".....	5.60	.72	"	.67
4. " ".....	5.60	.54	"	.67
5. " ".....	6.8	1.45	"	.79
6. " ".....	5.3	1.16	"	.67
7. " ".....	5.89	2.30	"	.60
8. " ".....	5.18	1.86	"	.81
<i>Cooked Foods.</i>				
1. Shredded Wheat.....	8.76	4.11	.26	*
2. " ".....	14.38	8.57	2.00	*
3. " ".....	14.92	9.64	2.46	*
4. " ".....	14.54	9.02	1.77	*
5. " ".....	13.96	8.65	2.39	*
6. " ".....	14.95	9.03	2.88	*
7. " ".....	14.48	8.81	2.76	*
1. Quaker Wheat Berries.....	28.1	23.52	3.34	2.33
2. " ".....	28.5	24.30	3.72	2.39
3. " ".....	23.9	19.55	3.51	2.14

TABLE NO. 4: PERCENTAGE OF WATER SOLUBLE MATERIAL IN DIFFERENT SAMPLES OF THE SAME BRAND OF FOODS.—*Concluded.*

Food.	Total Solids.	Alcohol ppt. (dextrin).	Cuprous oxide ppt. (sugar).	Soluble proteids.
<i>Cooked Foods.—Con.</i>				
4. Quaker Wheat Berries	27.5	22.96	3.30	2.27
1. Toasted Corn Flakes	28.6	19.86	5.16	.45
2. " "	28.1	19.25	5.81	.26
3. " "	28.2	19.82	6.64	.29
4. " "	28.4	19.60	5.38	.29
<i>Malted and Cooked Foods.</i>				
1. Canada Flakes	26.43	10.16	12.53	*
2. " "	30.66	*	*	*
3. " "	30.87	*	*	*
1. Malta Vita	29.01	13.72	9.02	*
2. " "	30.81	10.19	13.78	1.20
3. " "	25.09	9.35	7.91	1.51
4. " "	22.37	7.72	6.76	1.36
5. " "	19.97	8.86	2.58	1.44
1. Grape Nuts	41.84	12.67	19.14	1.64
2. " "	44.51	13.00	19.90	1.84
3. " "	44.83	13.36	22.74	1.76
4. " "	43.78	12.80	20.89	1.76
5. " "	46.14	12.97	22.41	1.68
1. Force	14.08	5.30	.61	*
2. " "	18.08	8.73	1.73	*
3. " "	17.40	8.31	2.53	*
4. " "	15.34	11.06	2.73	*
5. " "	16.59	11.67	3.38	*
6. " "	20.34	9.01	2.86	*
7. " "	16.70	10.22	4.23	*
1. Orange Meat	20.53	8.66	7.43	*
2. " "	26.77	*	*	*

* No determination made.

It is unnecessary to dwell on the results presented in the above table. As might be expected, there is very little variation in the amount and the make-up of the soluble matter in the various forms of farinas examined. There is, however, a noticeable difference in the amount of soluble matter extracted from the Tillson's oatmeal and the Quaker oats. If we are not mistaken, the former are kiln-dried by direct heat, whereas the latter are dried by means of steam. It would possibly be more difficult to control the temperature when the former method is used, and, as the greater the heat to which the oats are submitted, the greater the amount of the starch

dextrinized or rendered soluble, it is evident that the Tillson product has been heated slightly higher and that different lots have not been submitted to a uniform temperature.

Among the cooked, and the cooked and malted classes of foods there is sufficient variation in the amount of soluble matter to show that the different lots or batches of the same kind of food are not always prepared in exactly the same manner. It may be that in some lots more malt was used, or the malting period was longer, or that the toasting or parching process to which the foods are generally submitted was more thorough—all of which would cause variation in the percentage amounts of soluble matter.

INFLUENCE OF COOKING ON SOLUBILITY OF FOODS.

In general it may be safely stated that the thorough cooking of cereal foods is quite as important as the proportion of the nutrients which they contain. The chief purposes of cooking are: first, to sterilize the material, so that any undesirable bacteria, if accidentally present, may be destroyed; second, to improve flavor—making the food more appetizing and thus increasing its digestibility by stimulating the flow of digestive juices; and third, to so change the structure of the material, especially the carbohydrates, that they may be more readily digested. Possibly the last may be regarded as the most important, because, as previously stated, starch, which forms a very large proportion of these foods, is enclosed in cells, the walls of which are composed of crude fibre. This crude fibre is practically indigestible, and unless the walls which it forms are broken, comparatively little of the starch is digested and absorbed. In the cooking process, the contents of the cells expand and the walls burst, allowing the contents to come in direct contact with the water, when it is at least partially converted into soluble forms. Thorough cooking of the cereals really consists in rupturing these cell walls and in securing a maximum quantity of starch in a soluble form. The solubility of the protein is generally lessened by cooking, especially at high temperature. Long, slow cooking will soften the crude fibre and change the starch to soluble forms without materially decreasing the solubility of the proteids. Some experiments seem to show that, while the protein is rendered insoluble in the first part of the cooking, long continued action of the heat somewhat changes them into soluble forms.

It is very generally taught that oatmeal and farinas should be cooked six or eight hours before serving. The general practice throughout the country is, however, to cook for a very much shorter period, probably not more than twenty minutes to half an hour. To gather some information regarding the extent of the changes affected by the length of time the foods are cooked and to get some data for comparison with the foods sold as ready-to-serve, we cooked oat, wheat, and corn meals for periods of twenty minutes, two hours, five hours, and eight hours, and analyzed a water extract of each, prepared in the same manner as that previously

outlined in the study of solubility. The method of procedure was as follows: The meal was stirred into boiling water and the boiling continued vigorously for twenty minutes. A sample of the "porridge" was then taken out for examination and the remainder was placed in a double boiler and the cooking continued for eight hours at a lower temperature. At the two, five, and eight hour periods, a portion of the material was removed and used in determining soluble matter. The percentage soluble was calculated from the dry matter determined in a part of the sample similar to that extracted. No attempt was made to study exhaustively the nature of the changes produced by the cooking, but it was thought that a statement of the amount of soluble matter and the amount of crude dextrin, as stated in Table No. 5, alcohol precipitate, and the amount of sugar, or reducing materials, would give some indication of the nature and the extent of the changes the starch had undergone during the cooking process. The solubility of the proteids was also determined to ascertain what influence the long and short cooking had on these substances. The results form Table No. 5:

TABLE NO. 5: INFLUENCE OF COOKING ON THE SOLUBILITY OF FOODS.
Percentage Composition of Water Extract.

Name of Food.	Time cooked.	Solids.	Alcohol Precipitate. (dextrin.)	Cuprous oxide precipitate. (sugar.)	Soluble Proteids.
Rolled Oats.....	Uncooked	8.43	2.36	none	.86*
	20 minutes	14.95	3.36	"	0.89
	2 hours	18.79	4.49	"	1.57
	5 "	29.93	6.92	"	2.28
	8 "	34.30	8.77	"	3.39
Wheat Farina.....	Uncooked	6.97	trace	trace	2.18
	20 minutes	27.40	6.87	"	0.26
	2 hours	37.19	12.8	"	0.42
	5 "	38.37	.....	"	0.35
	8 "	39.99	15.1	"	0.65
Cornmeal.....	Uncooked	.....	.....	.....	.....
	20 minutes	15.29	11.42	none	0.32
	2 hours	13.78	9.60	"	0.40
	5 "	13.25	10.03	"	0.47
	8 "	20.03	16.84	"	0.60

*No determination made.

The above results indicate very clearly the influence of long cooking on the solubility of the foods. Apparently the wheat farina does not require to be cooked so long as either the cornmeal or the rolled oats, and that the soluble matter in the cornmeal did not increase so rapidly with the longer period of cooking as it did in the other foods. The results of

experiments made with rolled oats at the Minnesota Experiment Station* indicate that cooking (four hours) did not increase the solubility of the carbohydrates, and the theory is advanced that the difficulty experienced in digesting imperfectly cooked oatmeal is due to the large amount of mucilaginous proteid material which surrounds the starch grains and prevents their disintegration. It is further argued that when the oatmeal is thoroughly cooked, the protecting action of the proteid substance is overcome and the starch granules are sufficiently broken up to allow the digestive juices to act. The above results with oatmeal show that in our work there was an increase in the solubility of the starch, but that the change towards the dextrin compounds was not sufficient to allow much of it to be thrown down as an alcohol precipitate. There was also an increase in the solubility of the proteid substances. It is certainly evident that the longer periods of cooking increased the amount of soluble matter, and it is quite probable that this would decrease the labor involved in digesting the food.

With the wheat farinas 27.4 per cent. of the total dry matter of the food was soluble in water at the end of twenty minutes, which increased about 10 points when cooked for two hours. As the solubility was only slightly increased at the five and eight hour periods, it would appear as though the longer cooking was not required with this food. More crude dextrin is found in this case and a noticeable difference is observed in the proteid material as compared with the oatmeal. The heat has apparently coagulated, or rendered insoluble, the protein and it has only very slowly changed again under the influence of the longer cooking. The cornmeal, like the farina, under the influence of heat, formed considerable dextrin and the solubility of the proteids was very little changed by the long boiling.

A very interesting point in connection with these experiments is that the amount of soluble matter obtained from the oat, wheat, and corn meals after twenty minutes' cooking was greater than that from some of the so-called cooked foods and even greater than that obtained from some of the much advertised predigested foods; while the longer periods of cooking, especially with the rolled oats and farina, rendered nearly as great an amount of the dry matter soluble as was obtained from the best of the malted and cooked foods. It would certainly appear as though some of these ready-to-serve foods would be the better of further cooking before serving.

DIGESTIBILITY OF BREAKFAST FOODS.

A knowledge of the composition of a food is absolutely necessary in studying, or estimating, its nutritive value. But this is not sufficient, for it is only that part of the food which is actually digested and absorbed

*Minnesota Experiment Station Bulletin No. 74.

that serves to build tissue and carry on the life processes of the animal body. Therefore, to carry on the comparative study of the nutritive value of these foods further we determined the digestibility, or, as Dr. Atwater prefers terming it, the availability of the various food constituents contained in them.

Practical experiments of this nature are surrounded by many difficulties which it is not necessary to fully discuss at this time. Suffice it to say that the necessity of having a large number of results to offset individuality, the separation of the feces, and the arranging of a diet that is simple enough for the purpose of the experiment, and, at the same time, palatable, are among the chief difficulties in procuring reliable results. With reference to the last point, it may be stated that it is seldom possible to have the experiment conducted with the single food under investigation, for the flow of digestive juices is somewhat influenced by the degree with which the food is relished. A special food, such as any of those being studied, if eaten day after day alone, may become so distasteful to the subject of the experiment as to seriously interfere with normal digestion, or even to prevent the completion of the feeding period. On the other hand, while it is necessary to make the diet palatable, it must be simple in order that the digestibility of the specific food under investigation may be calculated. With the foods we studied, the addition of cream and sugar, the digestibility of which are known, was sufficient to make the diet palatable for the full period of the experiment.

In carrying out our digestion experiments, healthy young men of regular habits and taking a fair amount of exercise were used as subjects. They were interested in the experiments and volunteered for the work, and, consequently, willingly co-operated in every way to make the results accurate and the experiments a success. The feeding period in all the experiments was four days, and to offset the question of individuality, each experiment was conducted in triplicate.

Briefly, a general outline of the plan of the experiments is as follows: A definite weight of the food under investigation was cooked; from this each man was allowed to take as much as he wished, an accurate account being kept of the quantity taken, and at the end of the meal the remaining portion was weighed. From the weight of the dry meal taken and its weight when cooked and the weight of the portion eaten, it was possible to calculate the weight of the original meal eaten by each man at each meal, and, consequently, for all the meals throughout the four days of the experiment. Care was taken to have the porridge for each meal cooked alike, the time allowed for this purpose in all experiments, excepting some which will be mentioned later, was 20 minutes from the time the bubbling commenced. Each subject was allowed to use sugar and cream, of known composition, to suit his taste, but an accurate account was kept of the amount consumed. Knowing the composition of the meal, sugar, and cream, and the weight of each used, it was possible to calculate the weight of each constituent consumed. Before the first and after the last meal of

the experiment each subject was given a heavy dose of lampblack in capsules. This blackened the feces to such an extent that it was possible to make a fairly accurate separation of that part derived from the food eaten during the experiment. The lag of the lampblack on the wall of the intestine did, in some instances, make the dividing point somewhat indistinct, but in most cases it was quite clearly marked. The feces thus collected were carefully dried, weighed, and analyzed, and the amount of each constituent excreted calculated. Knowing the weight of each constituent eaten and excreted, and assuming that what is not excreted is digested and absorbed, we calculated the percentage digestibility of each constituent.

Strictly speaking, the results thus obtained do not represent actual or true digestibility, because the feces contain, in addition to the portions of the food not digested, some other materials, such as digestive juices and excretory products. On the other hand, these waste materials, or metabolic products, may be considered as representing the cost of digestion in terms of food ingredients. Consequently, while the figures arrived at may be a little below the true digestibility of the foods, they do represent the amount of food available to the body—for what is lost in the metabolic products must be replaced from the food.

The calculation of the amount of energy available to the body is a little more complicated because all the food digested and retained in the system is not fully oxidized. In computing the total fuel value of the food, we figured on the perfectly correct assumption that all the nutrients, excepting ash, may be completely burned. In the body, however, the protein digested is only partially oxidized, as a portion is excreted in the urine as urea, uric acid, etc., compounds capable of further oxidation. Consequently, in computing the amount of energy available to the body, account must be taken of the fuel value of these incompletely oxidized residual products of protein excreted in the urine. This may be done by collecting all the urine for the experimental feeding period and determining the heat of combustion of the organic matter in it. But, in the absence of any means of marking the urine for a given period, similar to that followed in the case of the feces, the only other alternative is to collect the urine throughout the experimental period and determine its fuel value. This may or may not be equal to that which would be formed by the unoxidized nitrogen compounds from the food under investigation. A much simpler method, and the only one open to us, is to calculate the available energy. It has been found in a large number of experiments conducted in Europe and on this continent that the average heat of combustion of the organic matter of the urine corresponding to one gram of digested protein amounts to 1.25 calories.† It is generally believed that the energy of the urine calculated by this factor is reasonably accurate. Consequently, the figures representing the per cent. of available energy

†Storrs Experiment Station Report, 1899, p. 100.

given in the following tables were obtained by multiplying the total number of grams of digestible protein by the factor 1.25, deducting the amount got in this way from the calories representing the fuel value of the digested portion of the food, dividing this by the number of calories of heat got from the total food and multiplying by 100. This gives the per cent. of the total energy of the food which is available to the body, or the co-efficient of availability of the food.

To calculate the digestibility of the breakfast food alone, it is necessary to know the digestibility of the several nutrients contained in the food fed with it. It will be remembered that cream and sugar only were eaten with the cereal. As the digestibility of these has been determined in many experiments, it was assumed that the averages of the results obtained would represent the digestibility of the nutrients in the present experiments. According to these results, 97 per cent. of the protein and 95 per cent. of the fat of cream, and 98 per cent. of the carbohydrates of cream and sugar would be digested;† or, in other words, that 3 per cent. of the protein, 5 per cent. of the fat, and 2 per cent. of the carbohydrates would not be digested and should be found in the feces. By use of these factors it is possible to calculate how much of the total feces should be credited to the cream and sugar and how much to the breakfast food experimented with. Having this data, it is an easy matter to figure the percentage digestibility of each of the nutrients of the cereal alone. Reference to the table showing this data reveals the fact that no figures are given for the digestibility of the fat in the breakfast food alone. This is because the amount of fat in the cereal is so small compared with that in the cream that it was thought that any figures obtained would not be reliable.

The data required to compute the available energy of the cereal alone consists of the total fuel value of the cereal, the fuel value of the feces for cereal alone, and the fuel value of the organic matter lost in the urine from the incomplete oxidation of the protein of the cereal. By adding the figures for the last two points together and subtracting the sum from the fuel value of the cereal alone, we have the fuel value, or the available energy, of the cereal alone, and by dividing this by the total fuel value of the cereal and multiplying by 100, we obtain the per cent. of the energy of the cereal available to the body. A full statement of the results of the 46 successfully completed experiments, figured out as above described, furnished a mass of data which it has been found more convenient to place in the appendix. The average results for each food, however, are given in Table No. 6.

†Storrs Experiment Station Report, 1899, p. 86.

TABLE NO. 6: AVERAGE PERCENTAGE DIGESTIBILITY OF THE DIFFERENT NUTRIENTS AND AVAILABILITY OF ENERGY OF THE TOTAL DIET.

Sample No.	Name of Food.	No. of Expts.	Organic Matter.	Crude Protein.	Crude Fat.	Carbo-hydrates.	Heat of Combustion Available.
TOTAL DIET.							
14	Granulated Oatmeal.....	3	93.1	77.4	89.5	97.6	90.5
35	Standard Oatmeal.....	3	96.1	89.6	94.6	98.4	93.8
44	Tillson's Pan Dried Oats.	6	94.9	82.9	93.1	98.4	92.6
42	Quaker Oats.....	4	94.8	84.0	94.5	98.1	92.4
45	Goldie's Farina.....	5	95.5	79.6	95.4	98.3	93.6
38	Stevens' Breakfast Food..	6	95.2	79.7	95.0	98.1	94.0
36	Wheat Germ.....	2	96.4	87.9	95.6	98.3	94.4
41	Rolled Wheat.....	3	93.6	79.2	95.6	96.1	93.3
46	Flaked Barley.....	3	94.8	76.6	95.0	97.7	93.8
47	Flaked Barley.....	2	94.1	75.9	93.3	97.2	91.7
37	Cornmeal.....	3	96.2	81.8	95.3	98.6	94.8
9	Orange Meat.....	2	94.0	81.4	94.9	95.3	92.1
43	Force.....	2	91.9	69.4	92.7	95.3	90.4
48	Norka.....	2	94.3	83.3	93.7	97.8	91.5
FOODS ALONE.							
14	Granulated Oatmeal.....	3	91.1	73.5	.....	97.5	86.9
35	Standard Oatmeal.....	3	95.5	88.1	.....	98.5	92.6
44	Tillson's Pan Dried Oats.	6	94.0	80.2	.....	96.8	90.8
42	Quaker Oats.....	4	94.1	81.3	.....	98.1	91.2
45	Goldie's Farina.....	5	94.6	73.6	.....	98.5	92.4
38	Steven's Breakfast Food.	6	94.1	72.1	.....	91.8	91.4
36	Wheat Germ.....	2	96.2	85.9	.....	97.9	93.7
41	Rolled Wheat.....	3	91.6	73.3	.....	94.8	90.6
46	Flaked Barley.....	3	93.7	71.3	.....	97.6	92.0
47	Flaked Barley.....	2	92.0	65.8	.....	96.8	87.4
37	Cornmeal.....	3	95.8	73.7	.....	98.9	94.6
9	Orange Meat.....	2	91.7	75.7	.....	94.6	90.5
43	Force.....	2	87.8	59.1	.....	94.3	85.9
48	Norka.....	2	93.4	81.0	.....	97.6	89.9

The foods used in the investigation, the sample number for reference to Table No. 1, and the number of digestion experiments with each are as follows:

Sample No.	14—Granulated oatmeal.....	3	digestion experiments.
“	“ 35—Standard oatmeal.....	3	“ “
“	“ 44—Tillson's Pan Dried Oatmeal...	6	“ “
“	“ 42—Quaker Oats.....	4	“ “
“	“ 45—Goldie's Farina.....	5	“ “
“	“ 38—Stevens' Breakfast Food.....	6	“ “
“	“ 36—Wheat Germ.....	2	“ “
“	“ 41—Rolled Wheat.....	3	“ “
“	“ 46—Flaked Barley.....	3	“ “

Sample No. 47—Flaked Barley	2	digestion experiments.
“ “ 37—Cornmeal	3	“ “
“ “ 9—Orange Meat	2	“ “
“ “ 43—Force	2	“ “
“ “ 49—Norka	2	“ “

All the foods excepting the last three were prepared by stirring the meal into boiling water and continuing the boiling for twenty minutes. The two samples of rolled oats and the two samples of farinas were also cooked for eight hours and carried through digestion experiments. In the following table the results obtained are averaged with those got from the short cooking period. Later on the results of the short and long cooking periods will be discussed separately. The barley Sample No. 46 is a new food, and is prepared by sprouting the grain, then drying, and flaking. The germination causes the breaking down of insoluble starch, proteids, and even fat into simpler compounds, which are more readily digested. Provided the germination has been allowed to proceed far enough, it would be very natural to suppose that this food would be more easily absorbed. It is being highly recommended as a food for infants and for people with weak digestion.

The above results show that there is no very wide difference in the digestibility of the foods investigated. In all the foods the carbohydrates are the most thoroughly digested and the protein the least. Over 96 per cent. of the organic matter of the total diet in the experiments with standard oatmeal, wheat germ, and cornmeal was digested. The wheat farinas are next in order, with the rolled oats and flaked barleys following closely. Force stands at the bottom of the list with 91.9 per cent. of the total organic matter digested. The differences in the availability of the heat of combustion, or energy, are also comparatively slight, and the foods rank in approximately the same order as in the digestibility of the organic matter.

The second part of the table gives the percentage digestibility of the different nutrients of the foods alone, calculated in the manner described earlier. Here again there is no wide difference in the amount of the various nutrients absorbed by the body and the foods rank in about the same order as when the total diet was considered.

Taking the results as a whole, it is apparent that the nutritive value of the oat, wheat, barley, and corn products is nearly equal. The granulated oatmeal is apparently not as well digested as the standard form. This may be due to the fact that the latter generally contains more of the germ of the grain than the former. The two preparations of rolled oats are practically equal in digestibility and in availability of the energy. This is also true with reference to the farinas, but the wheat germ, which was a good sample and true to name, is of slightly greater value than the farinas, and much superior to the rolled wheat. It is evident that of the two samples flaked barley No. 46, the one that was germinated in its

preparation, is slightly the better digested. The carbohydrates of corn-meal were very completely digested, and this food fully sustained its reputation as a good energy producer. Apparently the malting or pre-digesting to which Orange Meat, Force, and Norka have been submitted in the preparation process has not improved the completeness of their absorption. Even the carbohydrates, which would be the most affected by the previous treatment, are not so completely digested as in the other foods. Of these three foods, or, in fact, of all the foods experimented with, Force has given the poorest results. It will be remembered that in so far as the efficiency of the malting and cooking process can be measured by the solubility of the organic matter of Force, a wheat product, it was not equal to that produced by cooking wheat farinas for twenty minutes; and it is quite possible that this comparatively poor preparation has affected its digestibility.

There is one important factor, namely, ease of digestion, that has not been taken into consideration in the above discussion. All work done in the body must result in the expenditure of a certain amount of energy, and, consequently, while two foods may be equally completely digested, one may be more easily acted upon by the digestive juices, and, as a result, a greater amount of the total energy would be left for the production of new material or for work. We have no way of measuring the energy expended in doing the work of digestion, and, therefore, cannot give figures on this point; but it seems fair to assume that two foods prepared from the same kind of grain and cooked to the same extent, and of practically the same composition, will require an equal amount of energy to carry out the work of digestion. Thus, two samples of rolled oats prepared in the same manner and cooked for the same length of time would probably require an equal amount of energy in digestion. If, however, the preparation of the foods for consumption had increased the solubility of the nutrients of one food more than the other, it would probably be more easily digested. Thus Norka contains, according to our determination, 28 per cent. of soluble matter, while rolled oats, after cooking twenty minutes, contains nearly 15 per cent. But when the cooking process was continued for five hours, the solubility of the oat-meal was equal to that of Norka, and probably the energy of digestion would be about equal. It would be equally correct to argue that as Force contained only 17 per cent. of soluble material and wheat farinas cooked twenty minutes 27 per cent., the former would require a greater expenditure of energy to digest it than the latter. If this be true, then Force not only is less completely digested, as shown in the above table, but it also required the expenditure of more energy to do the work of digestion and thus the nutritive value of the food would be still further decreased.

But while we cannot measure the *ease* with which the digestion of foods is accomplished, we can, to some extent, estimate the *rapidity* of

the process. Snyder* has shown that when a definite amount of two lots of oatmeal were cooked for periods of thirty minutes and four hours, respectively, and treated with an equal quantity of malt, 6.1 per cent. of the starch of the oatmeal cooked for the shorter period, and 20.3 per cent. of that cooked for the longer period, was found to be digested at the end of ten minutes. Gudeman,† working along the same lines as Snyder, excepting that he used saliva and pancreatin instead of diastase of malt as the digestion agents, "found that the raw cereals, if sufficiently cooked, were as quickly digested as the best malted cereals, more quickly than prepared (cooked) cereals and a large majority of the so-called malted cereals."

Ease and rapidity of digestion are probably closely associated; for it is natural to assume that if a food is rapidly digested it will be done with the expenditure of less energy than if it required a long time. This is a point of considerable importance, especially to those who are inclined to be dyspeptic. From the data presented, it is evident that the ready-to-serve foods are no more completely digested than the raw foods when properly cooked; and, if we may judge from the percentage amount of soluble matter in the different foods when ready to serve, they are no more easily or rapidly digested.

DIGESTIBILITY OF FOODS, AS INFLUENCED BY SHORT AND LONG PERIODS OF COOKING.

It is quite generally stated that when oat meals, farinas, etc., are cooked for a long time they are made "more digestible." Data has been presented in Table No. 5 which show that the solubility of these foods is increased by the longer periods of cooking. Consequently, as argued above, they would be, as commonly expressed, "more digestible" in the sense of *ease* and *rapidity* of digestion. To ascertain whether this would be accompanied by a greater absorption of the several nutrients, we cooked two samples of rolled oats and two samples of farinas for twenty minutes and for eight hours and carried through digestion experiments in the same manner as previously described. To overcome the influence of individuality in digestion, the same men were used as subjects of the experiments with both methods of cooking, and all the conditions were kept as uniform as possible. The only exception to this was in the case of Sample No. 45, where two men were unable to go on with the second part of the experiment. The results obtained in this work, calculated to percentage, are given in the following table:

*Minnesota Experiment Station Bulletin No. 74, p. 153.

†Journal American Chemical Society, Vol. 26, p. 321.

TABLE NO. 7: AVERAGE PERCENTAGE DIGESTIBILITY OF THE DIFFERENT NUTRIENTS AND AVAILABILITY OF ENERGY AS INFLUENCED BY SHORT AND LONG PERIODS OF COOKING.

Sample No.	Name of Food.	No. of digestion expts.	Organic Matter.	Crude Protein.	Crude Fat.	Carbo-hydrates.	Heat of Combustion.
TOTAL DIET.							
44	Tillson's Oatmeal :						
	Short cooking	3	94.4	80.4	92.1	98.2	91.9
	Long cooking	3	95.4	85.3	94.1	98.5	93.2
42	Quaker Oats :						
	Short cooking	1	94.1	82.5	92.8	97.6	89.6
	Long cooking	3	95.0	84.5	95.1	98.2	93.3
45	Farina :						
	Short cooking	2	96.0	80.7	95.6	98.5	94.2
	Long cooking	3	95.2	78.8	95.2	98.2	93.4
38	Steven's Breakfast Food :						
	Short cooking	3	95.0	77.9	94.3	98.1	94.1
	Long cooking	3	95.4	80.3	95.7	98.0	93.8
BREAKFAST FOOD ALONE.							
44	Tillson's Oatmeal :						
	Short cooking	3	93.2	77.7	.....	98.3	89.8
	Long cooking	3	94.8	82.6	.....	98.7	91.8
42	Quaker Oats :						
	Short cooking	1	93.2	80.9	.....	97.6	89.4
	Long cooking	3	94.3	81.4	.....	98.3	91.7
45	Farina :						
	Short cooking	2	95.7	76.0	.....	98.6	93.3
	Long cooking	3	93.9	70.6	.....	98.4	91.5
38	Steven's Breakfast Food :						
	Short cooking	3	93.6	71.3	.....	98.1	90.7
	Long cooking	3	94.6	72.9	.....	98.0	92.1

The above results show that the longer period of cooking slightly increased the percentage digestibility of the two samples of rolled oats and the Stevens' Breakfast Food. In every case, with the single exception of the carbohydrates of the last named food, the improvement is noticeable in every constituent of the food examined, as well as in the percentage availability of the energy. It is worthy of note that the subjects of the digestion experiments with these foods were the same for the short and long periods of cooking, and, as a different lot of men were used in studying each of the foods, it cannot be said that the results represented the digestibility as determined by one set of men, and it would seem to more fully confirm the deduction that the long cooking slightly increased the digestibility of the food. Unfortunately two of the experiments with short cooking of Quaker Oats were lost. With the

farina, only one subject went through both experiments, and two new subjects were brought into the second part of the digestion experiment, thus somewhat destroying the value of the results.

One point worthy of special notice with all the foods is that the long cooking has not increased the percentage digestibility of the carbohydrates materially, and that the chief difference is found in the protein column. This is especially true with the oatmeals. On page 30 it was shown that long cooking increased the solubility of the proteid bodies of these materials, and this has doubtless influenced their digestibility. It will be remembered that twenty minutes' cooking rendered about twice as much of the total solids of wheat meals soluble in water as with the oatmeals. Apparently this has not increased the *completeness* of the digestion of these foods, although it may have rendered them more easily acted upon by the digestive juices.

It is true that the percentage increase in the digestibility of the foods when cooked for the longer period is not very large, and possibly the additional amount of nutrients represented would not be sufficient to warrant the longer cooking; but it must be remembered that the amount of energy required to digest the food will probably be lessened, and the palatability of the food will be improved. In general, it may be argued from the results presented that the longer cooking slightly improved the completeness of digestion, and probably ease of digestion and palatability, making them good nutritious foods, even for those with weak digestion powers. This is especially true of the oatmeals.

PALATABILITY.

Thorough relish for food is without doubt a factor which must be taken into consideration when we come to deal with digestibility. The secretion of the digestive juices which attack the ingested materials is largely under the control of the nervous system, and, therefore, it is reasonable to believe that the enjoyment of eating stimulates the secretory power of the glands which furnish them. No energy or nutritive value is added to a food by reason of its agreeable flavor or tasty appearance, but the amount of it which is finally appropriated by the body for the purpose of nourishment may be greatly increased thereby. It is held by some persons that dyspepsia is often contracted by reason of partaking of food which is not wholly relished, even though it is highly nutritious and well cooked. Palatableness of a food, therefore, determines to a great degree the amount of nutrients which will be extracted from it by the digestive organs. When anticipation alone sometimes "makes the mouth water," the potency of this factor is clearly and practically demonstrated.

These foods are rendered palatable by processes of parching, boiling, malting, and, in some cases, by the addition of other materials. That

they are palatable is abundantly evidenced by the fact that they are so extensively used; because, no matter how much they are advertised, people would not continue to use them unless they were palatable. Individual preference for different brands is natural, but this does not imply that the food preferred is more nutritious.

The extensive use of the prepared foods may be taken as an indication that they "agree" quite generally with those who eat them. Unfortunately, foods which are really wholesome and nutritious do not agree with every person, and when they do not their continued use may be harmful. Just why people differ in this respect is not definitely known; nor can any general principle be stated with reference to the matter. Consequently, it is necessary for each person to learn what foods "agree" with their own system. Palatableness and agreeableness of foods usually go together, but in some instances they do not.

ECONOMIC VALUE OF FOODS.

So far we have studied and discussed the various kinds of breakfast foods on the basis of chemical composition, energy value, digestibility, and palatability. It now remains for us to look into the economic side of the question and see which foods will furnish the largest amount of digestible matter for the least money. Before presenting the data on this point, it may be well to draw attention to the fact that, generally speaking, digested protein from one food is just as valuable as the digested protein of any other food, and the same is true of fat and carbohydrates. Consequently, we have no reason to believe that the digested protein of oatmeal is any more nutritious than that of the various farinas and the numerous kinds of "predigested foods;" or that the latter foods furnish forms of digestible protein, fat, and carbohydrates that are superior to those of any other food. There may be more of the digested nutrients used up in performing the work of digestion in one food than another, but as we cannot measure the amount so used, it is impossible to include it in our calculations relative to economic values. In the following table, the number of grams of digestible protein and carbohydrates, and the number of Calories of heat from ten cents' worth of a number of the foods is given. The calculations were made on the basis of the prices of these foods in Guelph, and on our own determinations of composition and digestibility. In the majority of cases, the weight per package and the weight of food in the package are the average of several weighings. For the sake of comparison, white, entire wheat, and Graham bread are included. These were calculated from data given in Bulletin No. 143 of the Office of Experiment Stations, Department of Agriculture, Washington, D.C.

TABLE NO. 8 : NUMBER OF GRAMS OF DIGESTIBLE PROTEIN, CARBOHYDRATES, AND NUMBER OF CALORIES FROM 10 CENTS WORTH OF THE FOODS.

Food.	How sold.	Price.	Grams of digestible Proteids.	Grams of digestible Carbo-hydrates.	Calories.
Granulated Oatmeal...	In bulk	7 lbs. for 25c	118.3	885.1	4,922
Rolled Oats.....	"	7 " 25c.	127.1	874.1	4,915
"	In packages	2 " 10c.	90.9	624.1	3,510
Farinas.....	In bulk	6 " 25c.	75.9	806.3	3,860
"	In packages	2 " 15c.	41.8	448.0	2,146
Wheat Germ	In bulk	7 " 25c.	118.9	950.5	4,861
Rolled Wheat.....	"	6 " 25c.	73.9	793.4	3,784
"	In packages	2 lbs. 13 ozs. 15c.	57.8	619.8	2,964
Flaked Barley	In bulk	2 lbs. for 10c.	59.6	683.1	3,035
Cornmeal.....	"	8 " 25c.	70.1	1175.1	5,316
"	In packages	3 " 10c.	62.6	1049.2	4,746
Orange Meat.....	"	20 ozs. for 15c.	26.9	279.3	1,341
Force	"	16 " 15c.	18.0	219.0	1,010
Norka.....	"	22 " 15c.	48.5	282.7	1,578
White Bread.....	In loaf	2½ lbs. for 10c.	90.4	546.8	2,817
Entire Wheat Bread...	"	2½ " 10c.	71.5	473.3	2,418
Graham Bread.....	"	2½ " 10c.	73.7	443.7	2,322

From the above figures some very interesting conclusions may be drawn. Obviously ten cents' worth of rolled oats, when sold in bulk, will furnish more digestible protein than any other food on the list; granulated oatmeal and wheat germ are practically alike and stand second in order in this respect; while malted or "predigested" foods supply the smallest quantity. In digestible carbohydrates, cornmeal stands first, wheat germ second, and the oatmeals third, with the malted foods again at the foot of the list. In the last column, which gives the energy value of the digestible matter of ten cents' worth of the foods, cornmeal ranks first, furnishing 400 calories of heat more than the oatmeals, which come second in order, and 455 more than wheat germ; while the same amount of money expended on Force will purchase food capable of producing only 1,010 calories of available energy, which is 4,306 less than that of cornmeal.

It may be argued that, as the "predigested" foods are sold in packages, they should be compared with the other foods put up in the same manner. When this is done, the differences in the energy values are not so wide; but, while there is a comparatively narrow margin between such farinas as Cream of Wheat, Meat of Wheat, etc., there is so much more protein and energy obtained from corn and oat meals that they are still very much cheaper. In this connection it is worthy of note that the goods sold in packages are very much more expensive than when sold in bulk. In the case of the farinas, only a little over half the nourishment would be obtained from the same money expended on package foods as when bought

in bulk. In the case of cornmeal the difference is not nearly so wide, but frequently the price of the meal sold in bulk is less than that given, sometimes as much as 10 pounds are given for 25 cents. The foods commonly sold in the package may be cleaner and more conveniently handled, but if they can be procured from a dealer who strives to keep them clean and who is selling sufficiently large quantities to insure a comparatively fresh supply, it is doubtful if very much is gained by purchasing them in this more expensive form.

In justice to the cooked and malted foods, it is only fair to point out that these foods are ready to serve, and, therefore, no expense is incurred in preparing them for the table. It is hardly possible to compute what it would cost under ordinary circumstances to make porridge from the oat or wheat meals; for, in many cases, they are cooked over wood or coal fires and along with the other cooking. Where a special fire is required, the cost of preparing the food will, to some extent, compensate for the difference in the original cost of the goods.

The data presented in the above table seem to clearly show that cornmeal is the most economical heat producer of the cereal foods. If the meal were used unbolted and the germ retained, it would be of even greater value. The oatmeals are nearly equal to the cornmeals in fuel values and contain much more of the proteids, or muscle-forming materials, and more ash, which is so necessary for the formation of bone. The oatmeals are also superior to the farinas, rolled wheat, and flaked barley in protein and carbohydrates and in fuel value. Wheat germ, when it is true to name, is a valuable food. In general, it is true that, while all the breakfast foods are good nutritious materials and that each of these foods have some quality which is specially prized by the individual using it, no breakfast food on the market will furnish so much actual nourishment for so little money as oatmeal. Another point brought out in the last table is that corn, oat, wheat, and barley meals, when sold in bulk and thoroughly cooked, are cheaper sources of digestible nutrients than bread.

SUMMARY.

Although there is such a large number of breakfast foods on the market, they are practically all made from five kinds of cereal grains. The great majority of those used in this country are made from two, oats and wheat, and nearly all of the ready-to-serve type are prepared from one—wheat. The chemical composition of the various foods shows that the method of preparation has not materially altered the proportion of the different nutrients of which they are composed, and that they correspond somewhat closely with the grain from which they were made. The exceptions to this are that in the oat products the amount of crude fibre has been reduced by removing the hull, and that in preparing the finer grades of cornmeal, the bolting process removes a portion of the fat. Whole

wheat has about the same amount of crude fibre as the prepared oatmeals, but the farinas have a part of this removed. Many persons consider that, since the bran layers of the wheat contain so much protein and ash material, they should be retained, even if the presence of the associated crude fibre does decrease the digestibility of the food. There would probably be some reason for this contention, especially when fed to young people, if these farinas formed the whole of the diet, but the ordinary mixed diet probably furnishes all the mineral matter which a healthy person requires. Moreover, the presence of crude fibre may injuriously increase peristaltic action, although, for this reason, it may be useful in cases of constipation. The breakfast foods prepared from oats are rich in protein and fat, and those of corn are rich in carbohydrates and poor in protein and fat. Rice is poor in protein and ash and rich in carbohydrates, containing very little crude fibre; while barley contains a fair proportion of all the nutrients, without an undue proportion of crude fibre.

The proportion of the various constituents of the different forms of breakfast foods digested does not differ very widely. Even the so-called "predigested" foods are not more completely digested than the others. What difference there is would go to show that they are not so fully absorbed as the oat and wheat meals when properly cooked.

Thorough cooking is an important factor with starchy foods, and, consequently, with all the foods under discussion. It not only makes the foods more palatable, but it also breaks down the walls of indigestible fibre which surround the starch granules and the other nutrients, and in general produces changes which render the food more susceptible to the action of the digestive juices, thus probably increasing the ease and rapidity of digestion. From the results obtained in our work, it would appear that the farinas do not require so long cooking as the rolled oats or cornmeal. Further, judging by the solubility of the organic matter, some of the much advertised prepared foods are not so well cooked as might be desired; for, while twenty minutes' cooking is not considered sufficient to properly prepare oatmeal porridge, it is found at the end of that time to contain more soluble matter than some of the prepared cooked foods, and nearly as much as some of the cooked and malted preparations. Farinas cooked for the same length of time were, with one exception, about as soluble as all of the so-called "predigested" foods examined. The percentage amount of soluble matter in a food may not form an absolutely correct basis for judging the efficiency of the cooking or malting process; but, as these processes tend to render certain parts of the food soluble, it certainly gives us a good basis of comparison. If this be true, we are right in concluding that some of the prepared foods should be further cooked before serving.

As regards palatability, one food does not seem to have much advantage over another. The mere fact that all are bought and used is sufficient evidence that they are palatable. Certain foods may "agree" with some people better than others. That is, after all, a matter of individuality and

each person must choose for himself; but with the great majority of people who use breakfast foods regularly, it is doubtful if the newer "malted" or "predigested" foods are more tasty or palatable than the older-fashioned oat and wheat porridge.

The cost of the numerous kinds of breakfast foods varies widely. The price per package may not be very different, but there is a wide difference in the actual weight of material in the package of the different brands of these foods, and this, together with the differences in composition and digestibility that exist, is sufficient to render the actual nourishment obtained from some foods very much more expensive than others. In many cases the market price has very little connection with the nutritive value, or even with the cost of the materials and preparation. The uncooked oat, wheat, and corn meals, especially those bought in bulk, are the cheapest per pound, both in weight of nutrients purchased and in the amount absorbed by the system. It is possible that the cost of cooking may be sufficient to materially offset this advantage; and that the convenience of the ready-to-serve foods may compensate for the higher cost. These considerations must, of course, vary with circumstances, and each person must decide them for himself.

In general, it may be stated that the various forms of breakfast foods on the market are all wholesome and nutritious foods. At present prices the uncooked oat, wheat, and corn meals are among our most economical sources of nutrients and energy, and, taking everything into consideration, it is probable that oatmeal ranks highest among these. It may not "agree" with everyone, but for those who can use it, there is no breakfast food which combines high protein content and energy producing qualities so well as oatmeal. The reason that prepared breakfast foods are more expensive is evidently not because they contain any more nourishment, but because of the way they are prepared, the manner they are put upon the market, and the cost of advertising. A curious name or appearance or a mysterious process of preparation, does not give them the extraordinary food value sometimes claimed. They may have a place in a hurry-up breakfast, but where economy is considered, there is nothing in the composition, digestibility, or palatability of these high-priced "predigested" foods to justify the extravagant price asked for some of them.

CONCLUSIONS.

1. The various foods agree in composition with the grains from which they are made.

2. The oat products are richest in protein and fat and poorest in carbohydrates; the corn and rice foods are lowest in protein and highest in carbohydrates; while wheat and barley materials stand between the oat and corn products in composition, but more nearly correspond with the former.

3. The ready-to-serve foods contain more soluble matter than the uncooked wheat, oat, and corn meals, but when these latter foods were cooked they were more soluble than some of the former class of foods.

4. The solubility of the ready-to-serve foods varied from 13.7 to 44.2 per cent. of the food, and this soluble part is composed principally of carbohydrates.

5. The oatmeals increased in solubility on cooking, up to eight hours, while with wheat meals, or farinas, no perceptible increase was noticed after two hours, solution being apparently due to insoluble starch being changed into soluble forms.

6. The digestibility of the various constituents of the different types of breakfast foods did not vary widely. Proteids varied most in this respect and were least digested in the ready-to-serve foods.

7. The carbohydrates of the so-called "predigested" foods were no better digested than those of the other foods.

8. The digestibility of oat and wheat meals was but slightly increased by prolonging the cooking from twenty minutes to eight hours, although the longer cooking increased palatability and probably ease of digestion.

9. The corn meals are the cheapest energy producers, but, taking other points into consideration, oatmeals are the most nutritious and economical; while the ready-to-serve foods are the most expensive.

10. Foods purchased in packages are much more expensive than those bought in bulk.

11. The older forms of breakfast foods, especially when sold in bulk, are among our cheapest food.

APPENDIX.

DETAILS OF DIGESTION EXPERIMENTS.

The sample numbers of the breakfast foods experimented with are given in order that the source and composition of the foods may be traced in Table No. 1. The initials of the subjects of the experiments are also given so that the influence of individuality in digestion may be traced.

The results of the digestion experiments are presented in much the same manner as employed by Dr. Atwater in his publication on Experiments on the Digestibility of Cereal Breakfast Foods, in the Sixteenth Annual Report of the Storrs Agricultural Experiment Station, 1904. Three digestion experiments were made with each food, and the detailed results of each experiment and the average co-efficients of digestibility of each food are given in the following tables.

The method of calculating the results have been fully explained in the previous part of the bulletin and need not be repeated here.

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS.

<i>Granulated or Pin Head Oatmeal</i> (Sample No. 14).	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Combustion.
<i>Experiment No. 1. Subject: F.A.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oatmeal.....	1,280.00	176.82	87.37	992.99	5,927
cream.....	314.89	28.89	264.00	22.00	2,716
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,894.89	205.71	351.37	1,314.99	9,873
Feces from total food.....	180.65	61.29	50.27	43.47	1,007
“ “ cream and sugar.....	.....	.86	13.20	6.44	154
“ “ oatmeal alone.....	.....	60.43	.....	37.03	853
Amount digested from total food..	1,714.24	144.42	301.10	1,271.52	8,866
“ “ “ oatmeal alone.....	.....	116.39	.....	955.96	.....
Energy of urine from total food.....	.....	.....	.....	.....	181
“ “ “ “ oatmeal alone.....	.....	.....	.....	.....	145
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	90.5	70.2	85.7	96.6	87.9
“ oatmeal alone.....	87.4	65.7	.....	96.3	83.2
<i>Experiment No. 2. Subject: W.J.H.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oatmeal.....	1,075.50	140.60	69.47	789.46	4,713
cream.....	314.89	28.89	264.00	22.00	2,716
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,690.39	169.49	333.47	1,111.46	8,659
Feces from total food.....	118.92	40.42	34.48	28.57	676
“ “ cream and sugar.....	.....	.86	13.20	6.44	154
“ “ oatmeal alone.....	.....	39.56	.....	22.13	522
Amount digested from total food..	1,571.47	129.25	298.99	1,082.89	7,983
“ “ “ oatmeal alone.....	.....	101.04	.....	767.33	.....
Energy of urine from total food.....	.....	.....	.....	.....	162
“ “ “ “ oatmeal alone.....	.....	.....	.....	.....	126
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	92.9	76.3	89.6	97.4	90.3
“ oatmeal alone.....	90.8	71.9	.....	97.2	86.0
<i>Experiment No. 3. Subject: C.B.T.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oatmeal....	890.50	123.10	60.79	690.80	4,124
cream.....	314.89	28.89	264.00	22.00	2,716
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,505.39	151.99	324.79	1,012.80	8,070
Feces from total food.....	63.02	21.77	20.43	12.90	371
“ “ cream and sugar.....	.....	.86	13.20	6.44	154
“ “ oatmeal alone.....	.....	20.91	.....	6.46	217
Amount digested from total food..	1,442.37	130.22	304.36	999.90	7,699
“ “ “ oatmeal alone.....	.....	102.19	.....	684.34	.....
Energy of urine from total food.....	.....	.....	.....	.....	163
“ “ “ “ oatmeal alone.....	.....	.....	.....	.....	128
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	95.8	85.6	93.3	98.7	93.4
“ oatmeal alone.....	95.2	83.0	.....	99.1	91.6
Average co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	93.1	77.3	89.5	97.6	90.5
“ oatmeal alone.....	91.1	73.5	.....	97.5	86.9

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Mid Cut or Standard Oatmeal</i> (Sample No. 35).	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1. Subject: W.J.H.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oatmeal.....	953.41	136.10	70.37	728.20	4,443
cream.....	202.11	21.10	163.00	18.00	1,714
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,455.52	157.21	233.37	1,046.20	7,387
Feces from total food.....	61.43	16.86	14.16	14.93	292
“ “ cream and sugar.....	.....	.63	8.15	6.36	102
“ “ oatmeal alone.....	.....	16.23	.....	8.57	190
Amount digested from total food..	1,394.09	140.35	219.21	1,031.27	7,095
“ “ “ oatmeal alone.....	.....	119.87	.....	719.63	.....
Energy of urine from total food...	.....	.....	.....	.....	175
“ “ “ “ oatmeal alone.....	.....	.....	.....	.....	150
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	95.8	89.3	93.9	98.6	93.7
“ oatmeal alone.....	95.1	88.1	.....	98.8	92.3
<i>Experiment No. 2. Subject: F.A.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oatmeal.....	1,125.45	160.65	83.07	859.61	5,245
cream.....	255.01	27.91	203.00	23.80	2,151
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,680.46	188.56	286.37	1,183.41	8,626
Feces from total food.....	59.20	20.29	15.44	14.58	323
“ “ cream and sugar.....	.....	.83	10.15	6.46	121
“ “ oatmeal alone.....	.....	19.46	5.29	8.12	202
Amount digested from total food..	1,621.26	168.27	270.93	1,168.83	8,303
“ “ “ oatmeal alone.....	.....	141.19	.....	850.49	.....
Energy of urine from total food...	.....	.....	.....	.....	210
“ “ “ “ oatmeal alone.....	.....	.....	.....	.....	176
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.5	89.2	94.6	98.8	93.8
“ oatmeal alone.....	96.2	87.9	.....	98.9	92.8
<i>Experiment No. 3. Subject: C.B.T.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oatmeal.....	673.42	96.12	49.71	514.37	3,137
cream.....	234.80	25.80	187.00	22.00	1,973
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,208.22	121.92	236.71	836.37	6,340
Feces from total food.....	47.72	11.91	10.84	17.87	244
“ “ cream and sugar.....	.....	.77	9.35	6.44	118
“ “ oatmeal alone.....	.....	11.14	.....	11.43	126
Amount digested from total food..	1,160.50	110.01	225.89	818.50	6,096
“ “ “ oatmeal alone.....	.....	84.98	.....	502.94	.....
Energy of urine from total food...	.....	.....	.....	.....	138
“ “ “ “ oatmeal alone.....	.....	.....	.....	.....	106
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.1	90.2	95.4	97.9	93.9
“ oatmeal alone.....	95.3	88.4	.....	97.8	92.7
<i>Average co-efficients of digestibility</i>	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.1	89.6	94.6	98.4	93.8
“ oatmeal alone.....	95.5	88.1	.....	98.5	92.6

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Short Cooking Tillsor's Oatmeal.</i> (Sample No. 44.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Combustion.
<i>Experiment No. 1. Subject: C.B.T.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oats	1,270.60	167.67	99.80	979.80	5,935
cream	326.09	28.34	270.75	27.00	2,796
sugar	300.00	.....	.....	300.00	1,230
Total	1,896.69	196.01	370.55	1,306.80	9,961
Feces from total food	120.60	42.74	33.86	24.49	658
“ “ cream and sugar .....	.....	.85	13.54	6.54	158
“ “ oats alone .....	.....	41.89	.....	17.95	500
Amount digested from total food ..	1,776.09	153.27	336.69	1,282.31	9,303
“ “ “ oats alone ..	.....	125.78	.....	961.85	.....
Energy of urine from total food ..	.....	.....	.....	.....	192
“ “ “ oats alone ..	.....	.....	.....	.....	157
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	93.7	78.2	90.9	98.1	91.4
“ oats alone	92.1	75.0	.....	98.1	88.8
<i>Experiment No. 2 Subject: K.</i> <i>G. McK.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oats	1,311.80	173.06	103.00	1,011.80	6,127
cream	331.78	28.90	276.13	27.75	2,852
sugar	300.00	.....	.....	300.00	1,230
Total	1,943.58	201.96	379.13	1,339.55	10,229
Feces from total food	97.00	31.53	26.56	21.66	522
“ “ cream and sugar .....	.....	.87	13.80	6.56	161
“ “ oats alone .....	.....	30.66	.....	15.10	361
Amount digested from total food ..	1,846.58	170.43	352.57	1,317.89	9,707
“ “ “ oats alone ..	.....	142.40	.....	996.70	.....
Energy of urine from total food ..	.....	.....	.....	.....	213
“ “ “ oats alone ..	.....	.....	.....	.....	178
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.1	84.4	93.0	98.4	92.8
“ oats alone	94.2	82.3	.....	98.5	91.2
<i>Experiment No. 3. Subject: F.A.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oats	1,306.80	172.39	102.65	1,007.50	6,102
cream	326.09	28.34	207.75	27.00	2,210
sugar	300.00	.....	.....	300.00	1,230
Total	1,932.89	200.73	373.40	1,334.50	9,542
Feces from total food	115.40	42.73	28.36	24.91	618
“ “ cream and sugar .....	.....	.84	10.35	6.54	128
“ “ oats alone .....	.....	41.89	18.01	18.37	490
Amount digested from total food ..	1,817.49	158.00	345.04	1,309.69	8,924
“ “ “ oats alone ..	.....	130.40	84.64	989.13	.....
Energy of urine from total food ..	.....	.....	.....	.....	198
“ “ “ oats alone ..	.....	.....	.....	.....	163
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.3	78.7	92.4	98.1	91.4
“ oats alone	93.4	75.7	.....	98.2	89.3
Average Co-efficients of digesti- bility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.4	80.4	92.1	98.2	91.9
“ oats alone	93.2	77.7	.....	98.3	89.8

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Long Cooking Tillson's Oatmeal.</i> (Sample No. 44.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Combustion.
<i>Experiment No. 1. Subject: F.A.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oats	1,178.00	155.40	92.53	908.41	5,502
cream	373.75	37.25	308.50	28.00	3,204
sugar	300.00	.....	.....	300.00	1,230
Total	1,851.75	192.65	401.03	1,236.41	9,936
Feces from total food	89.40	32.25	23.62	17.96	484
" " cream and sugar .....	.....	1.12	15.42	6.56	174
" " oats alone .....	.....	31.13	.....	11.40	310
Amount digested from total food ..	1,762.35	160.40	377.41	1,218.45	9,452
" " " oats alone ..	.....	124.27	.....	897.01	.....
Energy of urine from total food ..	.....	.....	.....	.....	201
" " " oats alone ..	.....	.....	.....	.....	155
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.7	83.2	94.1	98.5	93.0
" oats alone	94.4	80.0	.....	98.6	91.5
<i>Experiment No. 2. Subject C.B.T.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oats	1,190.30	157.00	93.51	917.95	5,560
cream	373.75	37.25	308.50	28.00	3,204
sugar	300.00	.....	.....	300.00	1,230
Total	1,864.05	194.25	402.01	1,245.95	9,994
Feces from total food	87.00	27.28	26.39	18.87	484
" " cream and sugar .....	.....	1.12	15.42	6.56	174
" " oats alone .....	.....	26.16	.....	12.31	310
Amount digested from total food ..	1,777.05	166.97	375.62	1,227.08	9,510
" " " oats alone ..	.....	130.84	.....	905.64	.....
Energy of urine from total food ..	.....	.....	.....	.....	209
" " " oats alone ..	.....	.....	.....	.....	164
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.3	85.9	93.4	98.5	93.1
" oats alone	94.6	83.3	.....	98.7	91.5
<i>Experiment No. 3. Subject K. G.</i> McK.	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oats	1,282.40	169.19	101.72	988.80	5,998
cream	373.75	37.25	308.50	28.00	3,204
sugar	300.00	.....	.....	300.00	1,230
Total	1,956.15	206.44	410.22	1,316.80	10,432
Feces from total food	82.50	27.48	20.73	19.35	434
" " cream and sugar .....	.....	1.12	15.42	6.56	174
" " oats alone .....	.....	26.36	.....	12.79	260
Amount digested of total food	1,873.65	178.96	389.49	1,297.45	9,998
" " " oats alone ..	.....	142.83	.....	976.01	.....
Energy of urine from total food ..	.....	.....	.....	.....	224
" " " oats alone ..	.....	.....	.....	.....	179
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.3	86.7	94.9	98.5	93.6
" oats alone	95.3	84.4	.....	98.7	92.5
Average Co-efficients of digesti- bility.	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.4	85.3	94.1	98.5	93.2
" oats alone	94.8	82.6	.....	98.7	91.8

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Short Cooking Quaker Oats.</i> (Sample No. 42.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1. Subject: J.B...</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—oats	1,896.70	273.36	150.18	1,435.80	9,096
cream	387.96	30.21	330.25	27.50	3,362
sugar	300.00	.....	.....	300.00	1,230
Total	2,584.66	303.57	480.43	1,763.30	13,688
Feces from total food	152.20	53.02	34.73	40.71	1,113
“ “ cream and sugar .....	.....	.90	16.50	6.55	427
“ “ oats alone .....	.....	52.12	.....	34.26	686
Amount digested from total food ..	2,432.46	250.55	445.70	1,722.59	12,575
“ “ “ oats alone .....	.....	221.24	.....	1,401.54	.....
Energy of urine from total food ..	.....	.....	.....	.....	313
“ “ “ oats alone .....	.....	.....	.....	.....	277
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.1	82.5	92.8	97.6	89.6
“ oats alone	93.2	80.9	.....	97.6	89.4
<i>Experiments Nos. 2 and 3 lost</i>					

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Quaker Oats (Long Cooking, (Sample No. 42).</i>	Total Organic Matter.	Protein	Fat.	Carbo- hydrates.	Heat of Combustion.
<i>Experiment No. 1. Subject: C.L.K.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials: oats.....	1073.00	154.70	85.00	812.30	5,034
cream.....	402.67	39.67	333.00	30.00	3,451
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,775.67	194.37	418.00	1,142.30	9,715
Feces from total food.....	69.00	21.56	18.40	16.25	365
“ “ cream and sugar.....	.....	1.17	16.65	6.60	188
“ “ oats alone.....	.....	20.39	.....	9.65	177
Amount digested from total food..	1,706.67	172.81	399.60	1,126.05	9,350
“ “ “ oats alone.....	.....	134.31	.....	802.65	.....
Energy of urine from total food.....	.....	.....	.....	.....	216
“ “ “ oats alone.....	.....	.....	.....	.....	168
Co-efficients of digestibility:	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.1	88.9	95.6	98.6	94.0
“ oats alone.....	96.0	86.8	.....	98.7	93.1
<i>Experiment No. 2. Subject: J.B.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials: oats.....	1,307.00	188.50	103.60	989.70	6,133
cream.....	402.67	39.67	333.00	30.00	3,451
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	2,009.67	228.17	436.60	1,319.70	10,814
Feces from total food.....	124.80	41.70	29.36	32.70	653
“ “ cream and sugar.....	.....	1.17	16.65	6.60	188
“ “ oats alone.....	.....	40.53	.....	26.10	465
Amount digested from total food..	1,884.87	186.47	407.24	1,287.00	10,161
“ “ “ oats alone.....	.....	147.97	.....	963.60	.....
Energy of urine from total food.....	.....	.....	.....	.....	233
“ “ “ oats alone.....	.....	.....	.....	.....	185
Co-efficients of digestibility:	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	93.3	81.3	93.3	97.5	91.8
“ oats alone.....	92.3	78.5	.....	97.4	89.4
<i>Experiment No. 3. Subject: W. J.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials: oats.....	855.90	123.90	68.05	650.30	4,030
cream.....	402.67	39.67	333.00	30.00	3,451
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,558.57	163.57	401.05	980.30	8,711
Feces from total food.....	69.50	27.16	14.97	14.55	359
“ “ cream and sugar.....	.....	1.17	16.6	6.60	188
“ “ oats alone.....	.....	25.99	.....	7.95	171
Amount digested from total food..	1,489.07	136.41	386.08	965.75	8,352
“ “ “ oats alone.....	.....	97.91	.....	642.35	.....
Energy of urine from total food.....	.....	.....	.....	.....	161
“ “ “ oats alone.....	.....	.....	.....	.....	122
Co-efficients of digestibility:	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	95.6	83.4	96.3	98.5	94.0
“ oats alone.....	94.7	79.0	.....	98.8	92.7
Average co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
of total food.....	95.0	84.5	95.1	98.2	93.3
“ oats alone.....	94.3	81.4	.....	98.3	91.7

TABLES SHOWING DETAILS OF DIGESTIVE EXPERIMENTS—*Continued.*

<i>Farina (Short Cooking)</i> (Sample No. 45.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1.</i> Subject, R.J.M.	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials : farina.....	977.58	105.98	14.86	852.10	4,257
cream.....	353.84	26.09	303.75	24.00	3,077
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,631.42	132.07	318.61	1,176.10	8,564
Feces from total food.....	51.60	21.82	12.98	14.09	307
" " cream and sugar.....	.....	.78	14.97	6.48	172
" " farina alone.....	.....	21.04	.....	7.61	135
Amount digested from total food..	1,579.82	110.25	305.63	1,162.01	8,257
" " " farina alone.....	.....	84.94	.....	844.49	.....
Energy of urine from total food...	.....	.....	.....	.....	138
" " " farina alone.....	.....	.....	.....	.....	101
Co-efficients of digestibility :	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.8	83.5	95.9	98.8	94.8
" farina alone.....	97.1	80.1	.....	99.1	94.4
<i>Experiment No. 2.</i> Subject, H.C.W.	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials : farina.....	1,050.10	113.92	15.98	915.70	4,575
cream.....	388.45	30.22	330.25	28.00	3,364
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,738.55	144.14	346.23	1,243.70	9,169
Feces from total food.....	83.30	32.96	16.23	22.77	439
" " cream and sugar.....	.....	.90	16.51	6.56	186
" " farina alone.....	.....	32.06	.....	16.21	253
Amount digested from total food..	1,655.25	111.18	330.00	1,220.93	8,730
" " " farina alone.....	.....	81.86	.....	899.49	.....
Energy of urine from total food...	.....	.....	.....	.....	139
" " " farina alone.....	.....	.....	.....	.....	102
Co-efficients of digestibility :	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	95.2	77.8	95.3	98.1	93.6
" farina alone.....	94.3	71.9	.....	98.2	92.2
<i>Experiment No. 3</i> Subject, G.E.S. Lost.					
Average co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.0	80.7	95.6	98.5	94.2
" farina alone.....	95.7	76.0	.....	98.6	93.3

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Farina, long cooking.</i> (Sample No. 45).	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Combus- tion.
<i>Experiment No. 1. Subject: C.M.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—farina	740.10	80.26	11.35	645.00	3,224
cream	354.56	38.31	288.25	28.00	3,022
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,394.66	118.57	299.60	973.00	7,476
Feces from total food	84.50	28.58	20.87	21.93	453
“ cream and sugar.....	.....	1.15	14.41	6.56	168
“ farina alone.....	.....	27.43	.....	15.37	285
Amount digested from total food..	1,310.16	89.99	278.73	951.07	7,023
“ “ farina alone .....	.....	52.83	.....	629.63	.....
Energy of urine from total food ...	.....	.....	.....	.....	113
“ “ farina alone .....	.....	.....	.....	.....	66
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	93.9	75.9	93.0	97.7	92.4
“ farina alone	91.5	65.8	.....	97.6	89.1
<i>Experiment No. 2. Subject: F.M.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—farina	694.46	75.30	10.56	605.30	3,014
cream	354.56	38.31	288.25	28.00	3,022
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,349.02	113.61	388.81	933.30	7,266
Feces from total food	60.30	25.14	13.09	13.71	326
“ cream and sugar.....	.....	1.15	14.41	6.56	168
“ farina alone.....	.....	24.09	.....	7.15	158
Amount digested from total food..	1,288.72	88.47	375.72	919.59	6,940
“ “ farina alone .....	.....	51.21	.....	598.15	.....
Energy of urine from total food ...	.....	.....	.....	.....	111
“ “ farina alone .....	.....	.....	.....	.....	65
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.5	77.8	96.6	98.5	93.9
“ farina alone	94.5	68.1	.....	98.8	92.6
<i>Experiment No. 3. Subject: H.C.W.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—farina	1,019.00	110.46	15.49	887.85	3,850
cream	354.56	38.31	288.25	28.00	3,022
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,673.56	148.77	303.74	1,215.85	8,102
Feces from total food	66.00	25.60	12.00	18.48	338
“ cream and sugar .....	.....	1.15	14.41	6.56	168
“ farina alone.....	.....	24.45	.....	11.92	170
Amount digested from total food..	1,607.56	123.17	291.74	1,197.37	7,764
“ “ farina alone .....	.....	86.01	.....	875.93	.....
Energy of urine from total food..	.....	.....	.....	.....	154
“ “ farina alone .....	.....	.....	.....	.....	108
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	96.1	82.8	96.0	98.5	93.9
“ farina alone	95.7	77.9	.....	98.7	92.7
Average co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.2	78.8	95.2	98.2	93.4
“ farina alone	93.9	70.6	.....	98.4	91.5

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Steven's Breakfast Food, short cooking.</i> (Sample No. 38).	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1. Subject: W.J.H.</i>	Gms.	Gms.	Gms.	Gms.	Gms.
Food materials—farina.....	937.70	96.27	11.54	824.30	4,055
cream	353.84	26.09	303.75	24.00	3,077
sugar	300.00	.....	.....	300.00	1,230
Total	1,591.54	122.36	315.29	1,148.30	8,362
Feces from total food	56.60	21.82	12.98	14.09	307
“ cream and sugar .....	.....	.73	15.19	6.48	172
“ farina alone .....	.....	21.04	.....	7.61	135
Amount digested from total food ..	1,534.94	100.54	302.31	1,134.21	8,055
“ “ farina alone .....	.....	75.23	.....	816.69	.....
Energy of urine from total food ...	.....	.....	.....	.....	126
“ “ farina alone .....	.....	.....	.....	.....	94
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	96.4	82.2	95.9	98.8	94.8
“ farina alone	96.4	78.1	.....	99.0	94.3
<i>Experiment No. 2. Subject: J.D.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—farina	971.10	99.70	11.95	853.66	4,200
cream	401.89	32.64	340.25	29.00	3,369
sugar	300.00	.....	.....	300.00	1,230
Total	1,672.99	132.34	352.20	1,182.66	8,799
Feces from total food	80.00	25.68	21.02	20.87	433
“ cream and sugar .....	.....	98.00	17.03	6.58	191
“ farina alone .....	.....	24.70	.....	14.29	242
Amount digested from total food ..	1,592.99	106.66	331.18	1,161.79	8,366
“ “ farina alone .....	.....	75.00	.....	839.37	.....
Energy of urine from total food ...	.....	.....	.....	.....	133
“ “ farina alone .....	.....	.....	.....	.....	94
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.2	80.6	94.0	98.2	93.5
“ farina alone	94.3	75.2	.....	98.3	92.0
<i>Experiment No. 3. Subject: M.F.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—farina	752.30	77.24	9.26	661.40	3,051
cream	388.47	30.22	230.25	28.00	2,434
sugar	300.00	.....	.....	300.00	1,230
Total	1,440.77	107.46	339.51	989.40	6,715
Feces from total food	93.10	31.26	24.26	25.78	516
“ cream and sugar .....	.....	.90	11.51	6.56	139
“ farina alone .....	.....	30.36	.....	19.22	377
Amount digested from total food ..	1,347.67	76.20	315.25	963.62	6,199
“ “ farina alone .....	.....	46.88	.....	642.18	.....
Energy of urine from total food ...	.....	.....	.....	.....	95
“ “ farina alone .....	.....	.....	.....	.....	59
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	93.5	70.9	92.9	97.4	94.0
“ farina alone	90.1	60.7	.....	97.1	85.7
Average co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.0	77.9	94.3	98.1	94.1
“ farina alone	93.6	71.3	.....	98.1	90.7

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Steven's Breakfast Food, long cooking.</i> (Sample No. 38).	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1. Subject: J.D.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—farina	775.12	79.58	9.54	681.40	3,352
cream	265.77	30.72	213.05	22.00	2,252
sugar	300.00	.....	.....	300.00	1,230
Total	1,340.89	110.30	222.59	1,003.40	6,854
Feces from total food	65.40	20.22	9.64	26.34	317
“ cream and sugar .....	.....	.91	10.65	6.44	131
“ farina alone .....	.....	19.31	.....	19.90	186
Amount digested from total food ..	1,275.49	90.08	212.95	977.06	6,517
“ “ farina .....	.....	60.27	.....	661.50	.....
Energy of urine from total food ..	.....	.....	.....	.....	113
“ “ farina .....	.....	.....	.....	.....	75
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.1	81.7	95.7	97.4	93.7
“ farina alone	93.8	73.2	.....	97.1	92.2
<i>Experiment No. 2. Subject: F.M.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—farina	784.00	80.50	9.65	689.22	3,391
cream	354.56	38.31	288.25	28.00	3,022
sugar	300.00	.....	.....	300.00	1,230
Total	1,438.56	118.81	297.90	1,017.22	7,643
Feces from total food	47.00	19.72	5.56	23.56	265
“ cream and sugar .....	.....	1.15	14.41	6.56	168
“ farina alone .....	.....	18.57	.....	7.00	97
Amount digested from total food ..	1,391.56	99.09	292.34	1,003.66	7,419
“ “ farina .....	.....	61.93	.....	682.22	.....
Energy of urine from total food ..	.....	.....	.....	.....	124
“ “ farina .....	.....	.....	.....	.....	77
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	96.7	83.4	98.1	98.6	95.4
“ farina alone	96.7	76.9	.....	98.9	94.8
	Gms.	Gms.	Gms.	Gms.	Gms.
<i>Experiment No. 3. Subject: W.J H.</i>	Gms.	Gms.	Gms.	Gms.	Gms.
Food materials—farina	1,059.20	108.70	13.03	930.84	4,002
cream	354.56	38.31	288.25	28.00	3,022
sugar	300.00	.....	.....	300.00	1,230
Total	1,713.76	147.01	301.28	1,258.84	8,254
Feces from total food	94.00	35.43	20.50	24.67	501
“ cream and sugar .....	.....	1.15	14.41	6.56	168
“ farina alone .....	.....	34.28	.....	18.11	333
Amount digested from total food ..	1,619.76	111.58	280.78	1,234.17	7,753
“ “ farina .....	.....	74.42	.....	912.73	.....
Energy of urine from total food ..	.....	.....	.....	.....	140
“ “ farina .....	.....	.....	.....	.....	93
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.5	75.9	93.2	98.0	92.2
“ farina alone	93.2	68.5	.....	98.0	89.4
Average co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.4	80.3	95.7	98.0	94.0
“ farina alone	94.6	72.9	.....	98.0	92.1

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Goldie's Wheat Germ.</i> (Sample No. 36.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Combustion.
	Gms.	Gms.	Gms.	Gms.	Cals.
<i>Experiment No. 1. Subject: W.J.H.</i>					
Food Materials—wheat germ..	907.59	108.40	27.58	758.80	4,007
cream	253.75	26.25	199.50	28 00	2,128
sugar	300.00	.....	.....	300.00	1,230
Total	1,461.34	134.65	227.08	1,086.80	7,365
Feces from total food	58.42	19.20	10.87	20.00	296
" cream and sugar .....	.....	.75	9.97	6.56	124
" wheat germ alone .....	.....	18.42	.....	13.44	172
Amount digested from total food..	1,402.92	115.45	216.21	1,066.80	7,069
" " germ alone ..	.....	89.98	.....	745.36	.....
Energy of urine from total food ..	.....	.....	.....	.....	144
" " germ alone ..	.....	.....	.....	.....	112
Coefficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	96.0	85.7	95.2	98.1	94.0
" wheat germ alone	95.5	83.0	.....	98.2	92.9
<i>Experiment No. 2. Subject: F.A.C.</i>					
Food materials—germ	1,164.07	139.40	35.45	975.40	5,151
cream	253.75	26.25	199.50	28.00	2,128
sugar	300.00	.....	.....	300.00	1,230
Total	1,717.82	165.65	234.95	1,303.49	8,509
Feces from total food	54.12	16.50	8.47	19.49	256
" cream and sugar .....	.....	.78	9.97	6.56	124
" germ alone .....	.....	15.72	.....	12.93	132
Amount digested from total food..	1,663.70	149.15	225.48	1,284.00	8,253
" " germ alone ..	.....	123.68	.....	952.47	.....
Energy of urine from total food ..	.....	.....	.....	.....	186
" " germ alone ..	.....	.....	.....	.....	154
Coefficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	96.8	90.0	95.9	98.5	94.8
" wheat germ alone	96.8	88.7	.....	97.6	94.5
<i>Experiment No. 3. Subject: C.B.T.</i>					
Lost.					
Average coefficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	96.4	87.9	95.6	98.3	94.4
" wheat germ alone	96.2	85.9	.....	97.6	93.7

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Rolled Wheat.</i> (Sample No. 41.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Combustion.
<i>Experiment No. 1. Subject: F.A.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—wheat	897.11	86.75	18.44	774.30	3,858
cream	387.87	21.87	338.00	28.00	3,387
sugar	300.00	.....	.....	300.00	1,230
Total	1,584.98	108.62	356.44	1,102.30	8,475
Feces from total food	109.57	25.36	18.87	47.92	522
“ “ cream and sugar .....	.....	.65	16.90	6.56	188
“ “ wheat alone .....	.....	24.71	.....	40.36	334
Amount digested from total food ..	1,475.41	83.26	337.57	1,054.38	7,953
“ “ “ wheat alone .....	.....	62.04	.....	733.94	.....
Energy of urine from total food ..	.....	.....	.....	.....	104
“ “ “ wheat alone .....	.....	.....	.....	.....	78
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	93.1	76.6	94.7	95.6	92.6
“ wheat alone	90.4	71.5	.....	94.8	89.3
<i>Experiment No. 2. Subject: W.J.H.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—wheat	803.40	77.69	16.51	693.40	3,455
cream	387.87	21.87	338.00	28.00	3,387
sugar	300.00	.....	.....	300.00	1,230
Total	1,491.27	99.56	354.51	1,021.40	8,072
Feces from total food	85.61	20.09	17.24	40.08	443
“ “ cream and sugar .....	.....	.65	16.90	6.56	188
“ “ wheat alone .....	.....	19.44	.....	33.52	255
Amount digested from total food ..	1,405.66	79.47	337.27	981.32	7,629
“ “ “ wheat alone .....	.....	58.25	.....	659.88	.....
Energy of urine from total food ..	.....	.....	.....	.....	99
“ “ “ wheat alone .....	.....	.....	.....	.....	73
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	93.6	79.8	95.1	96.0	93.3
“ wheat alone	92.3	77.7	.....	95.1	90.4
<i>Experiment No. 3. Subject: C.B.T.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—wheat	696.80	67.40	14.32	601.54	2,997
cream	387.87	21.87	338.00	28.00	3,387
sugar	300.00	.....	.....	300.00	1,230
Total	1,384.67	89.27	352.32	929.54	7,614
Feces from total food	79.41	16.83	10.42	38.93	356
“ “ cream and sugar .....	.....	.65	16.90	6.56	188
“ “ wheat alone .....	.....	16.18	.....	32.37	168
Amount digested from total food ..	1,305.26	72.44	341.90	890.61	7,258
“ “ “ wheat alone .....	.....	51.22	.....	569.17	.....
Energy of urine from total food ..	.....	.....	.....	.....	91
“ “ “ wheat alone .....	.....	.....	.....	.....	64
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.2	81.1	97.0	96.8	94.1
“ wheat alone	92.1	70.6	.....	94.6	92.2
Average Co-efficients of digesti- bility	p r cent.	per cent.	per cent.	per cent.	per cent.
Of total food	93.6	79.2	95.6	96.1	93.3
“ wheat alone	91.6	73.3	.....	94.8	90.6

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Flaked Barley.</i> (Sample No. 46.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1. Subject: F.A.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—barley	812.45	96.06	10.95	695.50	3,520
cream	460.01	23.01	413.00	24.00	4,075
sugar	300.00	.....	.....	300.00	1,230
Total	1,572.46	119.07	423.95	1,019.50	8,825
Feces from total food	94.25	31.55	19.11	27.97	479
“ “ cream and sugar .....	.....	.69	20.65	6.48	222
“ “ barley alone .....	.....	30.86	.....	21.49	257
Amount digested from total food ..	1,478.21	87.52	404.84	981.53	8,346
“ “ “ barley alone .....	.....	65.20	.....	674.01	.....
Energy of urine from total food ..	.....	.....	.....	.....	109
“ “ “ “ barley alone ..	.....	.....	.....	.....	39
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.0	73.5	95.5	97.3	93.3
“ barley alone	91.8	67.8	.....	97.0	91.5
<i>Experiment No. 2. Subject: W.J.H.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—barley	799.70	94.57	10.77	684.59	3,565
cream	460.01	23.01	413.00	24.00	4,075
sugar	300.00	.....	.....	300.00	1,230
Total	1,559.71	117.58	423.77	1,008.59	8,870
Feces from total food	64.06	22.49	14.06	17.83	335
“ “ cream and sugar .....	.....	.69	20.65	6.48	222
“ “ barley alone .....	.....	21.80	.....	11.35	113
Amount digested from total food ..	1,495.65	95.09	409.71	990.76	8,535
“ “ “ “ barley alone ..	.....	72.77	.....	673.24	.....
Energy of urine from total food ..	.....	.....	.....	.....	119
“ “ “ “ “ barley alone ..	.....	.....	.....	.....	91
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	95.9	80.9	96.7	98.2	94.9
“ barley alone	95.4	76.9	.....	98.4	94.2
<i>Experiment No. 3. Subject: C.B.T.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—barley	689.86	81.65	9.29	590.54	2,989
cream	460.01	23.01	413.00	24.00	4,075
sugar	300.00	.....	.....	300.00	1,230
Total	1,449.87	104.66	422.29	914.54	8,294
Feces from total food	79.94	25.72	20.33	22.20	429
“ “ cream and sugar .....	.....	.69	20.65	6.48	222
“ “ barley alone .....	.....	25.03	.....	15.36	207
Amount digested from total food ..	1,369.93	78.94	401.96	892.34	7,835
“ “ “ “ “ barley alone ..	.....	56.62	.....	575.18	.....
Energy of urine from total food ..	.....	.....	.....	.....	99
“ “ “ “ “ “ barley alone ..	.....	.....	.....	.....	71
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.5	75.4	95.2	97.6	93.3
“ barley alone	93.9	69.3	.....	97.3	90.4
Average Co-efficients of digesti- bility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.8	76.6	95.8	97.7	93.8
“ barley alone	93.7	71.3	.....	97.6	92.0

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS.—*Continued.*

<i>Flaked Barley.</i> (Sample No. 47.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Combustion.
<i>Experiment No. 1. Subject: C.B.T.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—barley.....	669.40	52.28	9.20	587.85	2,804
cream.....	286.43	30.43	232.00	24.00	2,436
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,255.83	82.71	241.20	911.85	6,470
Feces from total food.....	79.64	23.09	15.71	28.26	399
“ “ cream and sugar.....	.....	.91	11.6	6.48	43
“ “ barley alone.....	.....	22.18	.....	21.78	356
Amount digested from total food..	1,176.19	59.62	225.49	883.59	6,071
“ “ “ barley alone.....	.....	30.10	5.09	566.07	.....
Energy of urine from total food....	.....	.....	.....	.....	75
“ “ “ barley alone.....	.....	.....	.....	.....	37
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	93.7	72.1	93.5	96.9	90.2
“ barley alone.....	90.9	57.6	.....	96.3	85.9
<i>Experiment No. 2. Subject: F.A.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—barley.....	947.60	93.17	13.03	832.12	4,083
cream.....	286.43	30.43	232.00	24.00	2,436
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,534.03	123.60	245.03	1,156.12	7,749
Feces from total food.....	84.34	25.10	16.89	29.59	426
“ “ cream and sugar.....	.....	.91	11.60	6.48	43
“ “ barley alone.....	.....	24.09	.....	23.11	383
Amount digested from total food..	1,449.69	98.50	228.14	1,126.53	7,323
“ “ “ barley alone.....	.....	69.08	7.74	809.01	.....
Energy of urine from total food....	.....	.....	.....	.....	101
“ “ “ barley alone.....	.....	.....	.....	.....	71
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	94.5	79.7	93.1	97.4	93.2
“ barley alone.....	93.1	74.0	.....	97.2	88.8
<i>Experiment No. 3. Subject :</i> W.J.H.—Lost.					
Average co-efficients of digesti- bility.	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	94.1	75.9	93.3	87.2	91.7
“ barley alone.....	92.0	65.8	.....	96.8	87.4

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Cornmeal.</i> (Sample No. 37.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1. Subject: K.G.Mc.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—cornmeal....	987.80	75.00	7.08	902.50	3,810
cream.....	315.30	38.60	248.70	28.00	2,655
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,603.10	113.60	255.78	1,230.50	7,695
Feces from total food.....	51.25	19.91	9.41	13.39	250
“ “ cream and sugar.....	.....	1.16	12.44	6.56	152
“ “ cornmeal alone.....	.....	18.75	.....	6.83	98
Amount digested from total food..	1,551.85	93.69	246.37	1,217.11	7,445
“ “ “ cornmeal.....	.....	56.25	.....	895.67	.....
Energy of urine from total food...	.....	.....	.....	.....	117
“ “ “ cornmeal.....	.....	.....	.....	.....	70
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.8	82.5	96.3	98.9	95.2
“ cornmeal alone.....	96.8	75.0	.....	99.2	95.5
<i>Experiment No 2. Subject: J.E.B.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—cornmeal....	958.20	72.76	6.88	875.50	4,083
cream.....	315.30	38.60	248.70	28.00	2,655
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,573.50	111.36	255.58	1,203.50	7,968
Feces from total food.....	60.36	19.87	14.39	14.38	310
“ “ cream and sugar.....	.....	1.16	12.44	6.56	152
“ “ cornmeal alone.....	.....	18.71	.....	7.82	158
Amount digested from total food..	1,513.14	91.49	241.19	1,189.12	7,658
“ “ “ barley.....	.....	54.05	.....	868.94	.....
Energy of urine from total food...	.....	.....	.....	.....	114
“ “ “ barley.....	.....	.....	.....	.....	68
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.2	82.2	94.4	98.8	94.7
“ cornmeal alone.....	95.8	74.3	.....	99.1	94.4
<i>Experiment No 3. Subject: C.R.K.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—cornmeal....	908.81	69.01	6.53	830.40	3,872
cream.....	287.60	36.30	225.30	26.00	2,416
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	1,496.41	105.31	231.83	1,156.40	7,518
Feces from total food.....	63.62	20.44	11.22	20.77	310
“ “ cream and sugar.....	.....	1.09	11.26	6.42	138
“ “ cornmeal alone.....	.....	19.35	.....	14.35	172
Amount digested from total food..	1,432.79	84.87	220.61	1,135.63	7,208
“ “ “ cornmeal.....	.....	49.66	.....	816.05	.....
Energy of urine from total food...	.....	.....	.....	.....	106
“ “ “ cornmeal.....	.....	.....	.....	.....	62
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	95.7	80.6	95.2	98.2	94.5
“ cornmeal alone.....	94.9	71.9	.....	98.3	93.9
Average co-efficients of digesti- bility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	96.2	81.8	95.3	98.6	94.8
“ cornmeal alone.....	95.8	73.7	.....	98.9	94.6

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Orange Meat.</i> (Sample No. 9.)	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1. Subject: F.A.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—orange meat..	1,272.95	120.30	15.56	1,109.25	5,402
cream	293.13	40.78	224.35	28.00	2,445
sugar	300.00	.....	.....	300.00	1,230
Total	1,866.08	161.08	239.91	1,437.25	9,077
Feces from total food	132.42	32.01	14.55	68.68	606
" " cream and sugar .....	.....	1.22	11.21	6.56	138
" " orange meat alone .....	.....	30.79	.....	62.12	468
Amount digested from total food..	1,733.66	129.07	225.36	1,368.51	8,471
" " " orange meat .....	.....	89.51	.....	1,047.13	.....
Energy of urine from total food...	.....	.....	.....	.....	161
" " " orange meat .....	.....	.....	.....	.....	112
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.0	80.1	93.9	95.2	91.5
" orange meat alone	91.1	74.4	.....	94.4	90.0
<i>Experiment No. 2. Subject: W.J.C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—orange meat..	993.75	93.91	12.15	865.88	4,217
cream	265.68	38.18	201.60	26.00	2,206
sugar	300.00	.....	.....	300.00	1,230
Total	1,559.43	132.09	213.75	1,191.88	7,653
Feces from total food	95.06	22.80	8.62	50.40	421
" " cream and sugar .....	.....	1.15	10.08	6.52	127
" " orange meat alone .....	.....	21.65	.....	43.88	294
Amount digested from total food..	1,464.37	109.29	205.13	1,141.48	7,232
" " " orange meat .....	.....	72.26	.....	822.00	.....
Energy of urine from total food...	.....	.....	.....	.....	137
" " " orange meat .....	.....	.....	.....	.....	90
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	93.9	82.7	95.9	95.3	92.7
" orange meat alone	92.2	76.9	.....	94.8	90.9
Average co-efficients of digesti- bility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.0	81.4	94.9	95.2	92.1
" orange meat alone	91.6	75.7	.....	94.6	90.5

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Continued.*

<i>Force.</i> [Sample No. 43.]	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of combustion.
<i>Experiment No. 1. Subject: M. F. C.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—force	814.10	86.22	18.72	688.18	3,502
cream	355.83	39.33	308.50	28.00	3,215
sugar	300.00	.....	.....	300.00	1,230
Total	1,469.93	125.55	327.22	1,016.18	7,947
Feces from total food	96.98	28.52	19.69	33.59	489
" cream and sugar .....	.....	1.18	15.42	6.56	177
" force alone .....	.....	27.34	.....	27.03	312
Amount digested from total food..	1,372.95	97.03	307.53	982.59	7,458
" " force alone .....	.....	58.88	.....	661.15	.....
Energy of urine from total food..	.....	.....	.....	.....	121
" " force alone .....	.....	.....	.....	.....	74
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	94.8	77.3	93.9	96.7	92.3
" force alone	90.9	68.2	.....	96.1	88.9
<i>Experiment No. 2. Subject: C. M.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—force	1,161.95	123.10	26.72	982.35	5,002
cream	355.83	39.33	308.50	28.00	3,215
sugar	300.00	.....	.....	300.00	1,230
Total	1,817.78	162.43	335.22	1,310.35	9,447
Feces from total food	200.45	62.65	28.33	79.48	959
" cream and sugar .....	.....	1.18	15.42	6.56	177
" force alone .....	.....	61.47	.....	72.99	782
Amount digested from total food..	1,617.33	99.78	306.89	1,230.87	8,488
" " force alone .....	.....	61.63	.....	909.43	.....
Energy of urine from total food..	.....	.....	.....	.....	124
" " force alone .....	.....	.....	.....	.....	77
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	88.9	61.4	91.5	93.9	88.5
" force alone	84.7	50.0	.....	92.5	82.8
<i>Average co-efficients of digestibility</i>	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food	91.9	69.4	92.7	95.3	90.4
" force alone	87.8	59.1	.....	94.3	85.9

TABLES SHOWING DETAILS OF DIGESTION EXPERIMENTS—*Concluded.*

<i>Norka.</i> [Sample No. 48.]	Total Organic Matter.	Protein.	Fat.	Carbo- hydrates.	Heat of Com- bustion.
<i>Experiment No. 1. Subject :</i>					
K. G. Mc.	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—Norka.....	1,639.85	239.50	85.24	1,262.25	7,481
cream.....	293.13	40.78	224.35	28.00	2,445
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	2,232.98	280.28	309.59	1,590.25	11,156
Feces from total food.....	149.75	54.98	25.56	45.04	747
" cream and sugar.....	.....	1.22	11.21	6.56	138
" Norka alone.....	.....	53.76	.....	38.48	609
Amount digested from total food..	2,083.23	225.30	284.03	1,545.21	10,409
" " Norka alone.....	.....	185.74	.....	1,223.77	.....
Energy of urine from total food..	.....	.....	.....	.....	282
" " Norka alone.....	.....	.....	.....	.....	232
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	93.3	80.4	91.7	97.2	90.8
" Norka alone.....	92.0	77.6	.....	96.9	88.8
<i>Experiment No. 2. Subject: C.B.T.</i>	Gms.	Gms.	Gms.	Gms.	Cals.
Food materials—Norka.....	1,679.00	245.25	87.30	1,292.75	7,559
cream.....	293.13	40.78	224.35	28.00	2,445
sugar.....	300.00	.....	.....	300.00	1,230
Total.....	2,272.13	286.03	311.65	1,620.75	11,234
Feces from total food.....	106.00	39.39	23.41	27.59	563
" cream and sugar.....	.....	1.22	11.21	6.56	138
" Norka lone.....	.....	38.17	.....	21.03	425
Amount digested from total food..	2,166.13	246.64	288.24	1,593.16	10,671
" " Norka alone.....	.....	207.08	.....	1,271.72	.....
Energy of urine from total food..	.....	.....	.....	.....	308
" " Norka alone.....	.....	.....	.....	.....	259
Co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	95.3	86.2	95.7	98.3	92.2
" Norka alone.....	94.7	84.4	.....	98.3	90.9
Average co-efficients of digestibility	per cent.	per cent.	per cent.	per cent.	per cent.
Of total food.....	94.3	83.3	93.7	97.7	91.5
" Norka alone.....	93.3	81.0		97.6	89.9

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE

Experiments in Hatching and Rearing Chickens.

BY W. R. GRAHAM, POULTRY MANAGER AND LECTURER.

For a number of years the Poultry department has been endeavoring to locate the cause or causes for the large losses of young chickens, particularly of those hatched artificially. Numerous visits have been made to farms where chicks were being grown both naturally and artificially. The most casual observer would have noticed that, upon the average, the chickens hatched naturally were more thrifty and vigorous. I have often seen, however, some choice chicks that were hatched by the artificial means, and also a few chicks hatched by hens that were far from first-class. In a general way, nearly all large poultry farms that I have visited, where 1,000, or even say 500, chickens are hatched annually, there was a very heavy death rate, so heavy as to render the business unprofitable. The death rate among chicks hatched artificially, when there is not more than one hundred hatched, is proportionately not so heavy, so far as I can judge from correspondence and observation; yet even among these growers, numerous complaints are made, and the average mortality is very serious. The questions to my mind are as follows:

(a) Is artificial incubation to blame? If so, wherein does it differ from natural incubation?

(b) Is the heavy mortality due to inferior breeding stock?

(c) Are the methods of feeding and brooding the causes of the trouble?

All the questions have to be considered seriously, and it is very difficult to separate them so as to be positive that one and only one is influencing the results. Therefore the writer would ask the reader to carefully consider the methods of selecting eggs for incubation, as well as the methods of feeding and brooding the chickens, before drawing conclusions as to incubation. Many of these experiments, if not all, will have to be duplicated for a number of years.

In taking up the question of how a hen hatches eggs, we at once felt the necessity of a careful study in every detail, and to do this we asked the co-operation of the departments of Physics and Chemistry. The work done by these departments is given in this Bulletin. What may be termed the practical work, or that which may be done by any poultryman who will take the trouble, was done by the Poultry department.

The experiments were commenced in the summer of 1906 and were reported upon in the Annual Report of the College. The experiments of 1906 indicated that a hen was a better hatcher than an incubator, and that so far as we had learned, she differed from incubators in having less evaporation of the egg content, and in having a much higher amount of carbonic acid gas in the air immediately surrounding the eggs. Last year we kept no detailed record of the mortality of the chicks. The July and August chickens lived and grew fairly well. This may have been due to the fact that the machines of 1906 were washed with a solution of zenoleum, mainly for the reason that they then looked cleaner and had less of the incubator odor. We thought the good results obtained were due to the fresher air of the incubator room, but as the same room and many of the same machines were used this year, we cannot maintain the idea as being correct.

We have this season tried to make the conditions in the machines more like those found under the hen. It will be noticed in the tables that we have operated nearly all the makes of incubators, at times, different to the manufacturers' directions; hence, one should not judge a machine by these results.

EGGS USED FOR HATCHING.

It is a well known fact that eggs vary in their power of hatching. Some eggs are infertile; some are fertilized, but the germ is so weak that it dies early in the period of incubation; others reach practically the hatching stage and then die. The power of hatching is influenced by breeding, feeding, housing, etc. Where one proposes to follow the vitality of chicks or even to consider any phase of the incubation or rearing problems, it becomes necessary to have eggs as nearly alike as possible; hence, we have used in nearly all the experiments, eggs laid by the same individual hens. We have been trap-nesting over 500 hens and have used such eggs in this work. We have also used shuffled eggs which were purchased from outside sources. By shuffled eggs is meant, simply, a common box or basket of eggs such as would be gathered from an ordinary flock.

The tables which follow give the results obtained from the individual eggs, with the exception of the mortality column, which gives the mortality of the chicks from all sources. The results obtained from the shuffled eggs are omitted for the reason that we failed to get anywhere near an equal division of the eggs as to fertility, etc. We regret that the results should be so. We tried many methods of mixing and separating the eggs with the results as above mentioned. The mortality of the chicks from both kinds of eggs was very nearly the same; therefore, there was no necessity of separating the deaths from each kind of eggs.

If the method of incubating has no effect upon vitality, and the same hen's eggs are in each machine, then the chicks should live in nearly the same proportions, provided that the brooding, feeding, and care are the

same. On the other hand, should there be a considerable variation in mortality with brooding, feeding, etc., alike, we must then come to the conclusion that the method of incubating influences the chick's vitality.

The incubators used were divided into three groups in order that we might set a number of machines each week throughout the natural hatching season. Later in the season these groups were somewhat broken up.

In many instances hens were set upon eggs laid by the same individuals as those used in the machines. We tried to have a number of hens to set at the same time we set the incubators, but owing to a shortage of "cluckers" we were not always able to do so. We give a table which shows the results as obtained from each method of incubating and brooding.

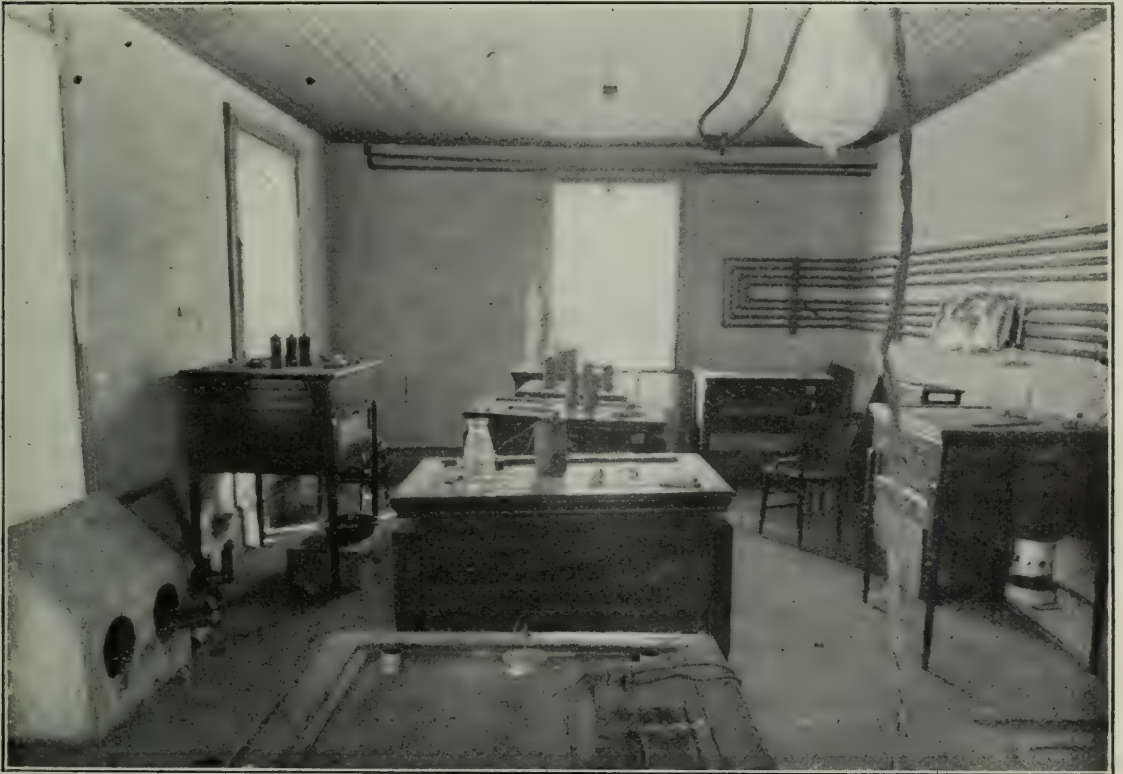


Fig. 1.—The Experimental Incubator Room.

INCUBATORS USED IN THESE EXPERIMENTS.

Chatham Incubator. Manufactured by the Chatham Incubator Co., Chatham, Ont. This machine is classed under the radiant type of machine, and can be operated with or without moisture. There are moisture pans sent out with each machine.

Peerless Incubator. Manufactured by the Lee-Hodgins Co., Pembroke, Ont. This is a hot water machine and, according to the manufacturer's directions is to be operated without moisture.

Hearson Incubator. Manufactured in England and sold by Spratt's Patent, Notre Dame Street, Montreal. This machine is also of the hot water type. It has an updraft circulation of air, which makes it, in this respect, in a class by itself. When operating, moisture should be used in this machine, according to the manufacturer's directions.

Model Incubator. Manufactured by the Model Incubator Co., of Toronto, and Buffalo. This is a hot air machine of the diffusion type. The manufacturer's directions call for the machine to be operated without moisture. It differs from the Cyphers incubator in that the bottom of the machine is slatted. There are other differences, but these are not so marked.

Cyphers Incubator. Manufactured by the Cyphers Incubator Co., Buffalo. These machines are of the hot air diffusion type, and are supposed to be used without moisture. We have divided the machines here into the two types, known as the 1905 and 1906. The 1906 machine is much deeper than the 1905 machine, and for this reason we thought it well to divide the machines.

Prairie State Incubator. Manufactured by the Prairie State Incubator Co., Homer City, Pa., U.S.A. Of these machines we have two types, one known as the Open Bottom Prairie State, which is a radiant machine. Moisture pans are sent out with these machines, so that moisture may be used in limited quantities. This machine has a cloth bottom. The 1907 Prairie State is somewhat different in design from any other make. This machine is a combination of the radiant and the diffusion types. It also has a large moisture pan in the bottom, and the ventilation is somewhat different from most other makes. These machines are to be operated with moisture according to the manufacturer's directions.

Cortland Incubator. Manufactured by the Cortland Incubator Co., Cortland, N.Y., U.S.A. This is a diffusion incubator with a large moisture pan in the bottom of the machine.

Climax Incubator. Manufactured by the Climax Incubator Co., Castorland, N.Y. This machine is somewhat of a combination of the radiant and diffusion type. It is practically an open bottom incubator, but has sent with it a large moisture pan to be used in the bottom of the machine if the operator so desires.

Continuous Hatcher. Manufactured by the Hacker Incubator Co., St. Louis, Mo. This machine is different in design from any of the others. Ventilation is by diffusion. The air passes through the side walls of the incubator, which are made of cloth. With this incubator there is a limited supply of moisture.

Of the makes mentioned, nearly all of the machines are of about 100 egg capacity. By this, we mean that they may vary in capacity from 100 to 140 eggs. The 1906 Cyphers, Peerless, and Continuous Hatcher are 200 egg machines. The Continuous Hatcher and the Climax incu-

bators were received late in the season, so could not be included in earlier trials. We are not prepared to state what these machines may do in the way of hatching or in the production of normal chickens earlier in the season.

We have tried operating nearly all the incubators with and without moisture. Had we all of the incubators of one make or one type we could have given more satisfactory results as regards methods of operating incubators to decrease the mortality in the chicks. We have not had in every instance what would be called a check machine in each series. While the results appear to point strongly in favor of the use of certain materials in the way of decreasing the death rate of young chicks, yet these results would be far more satisfactory had we had check machines in each series.

The tables given will indicate what each of the machines has done for us in our incubator room. Those who have not had any serious mortality in incubator chickens may not have to pay much attention to the preventives suggested here, but my observation has led me to believe that sooner or later, practically all operators have trouble in rearing incubator chickens.

OPERATING THE MACHINES.

Our aim was to operate the machines so that the chicks would begin hatching on the night of the twentieth day. Our experience with hens was that they would average to begin hatching at this time. The machines were run at a temperature of 100° to 101° , with a clinical thermometer lying on the top of the eggs. A record was kept of the temperatures, also of the temperatures as indicated by the hang-up thermometer. In some makes of incubators it was necessary the first week to run the hang-up thermometer at 105° to get 100° on the eggs. With the temperature at 101° and very little airing, except that given while the eggs were being turned, we seldom failed to get the hatch off on time. The temperature the first ten days was usually a little under 101° , and the last ten days nearly 102° . It was difficult, at times, to keep up the temperature at the beginning of the hatch, and equally as troublesome to keep it down toward hatching time.

The eggs were turned twice daily after the third day and were tested on the ninth day. No test was made after this. We ceased turning the eggs on the seventeenth day when moisture was used, and pans used in the bottom of the machines were removed on the night of the nineteenth day or the morning of the twentieth.

BROODING.

Two makes of brooders have been used in brooding the chickens: the Prairie State Universal Hover and Out-door Brooder, and the In-door and Out-door Model. Most of the brooding has been done with the Universal Hovers, as we had more of them. It may be stated here that we

did not find any marked difference in the mortality of the two brooders. The hovers were attached to colony houses, and these in turn were placed about the poultry yards, in the College orchards, and in the farm corn-field. The chickens brooded by hens were placed in the same fields, and the method of feeding was the same for all.

Chicks from each incubator in a series were placed in the brooder. Each brooder had some chickens from all machines in the series, so that should the brooders vary, or the care be not the same, some chickens from each machine received an equal share, whether it was good or bad. It may be interesting to know that there was not in any series any marked



Fig. 2.—This cut shows the method of Brooding, etc.

difference between the different brooders used, but there was a marked difference in the hens used as brooders.

FEEDING.

We tried to adopt a plan of feeding that could easily be used by most growers. I would like to call attention to the fact that these chickens were grown out-of-doors and not under hot-house conditions, such as we get in January, February, and March; and further, the plan about to be given is not satisfactory for winter use, mainly because the chicks do not get sufficient exercise.

The chicks were usually placed in the brooders when forty-eight hours old, but a few were put in when nearly twenty-four hours old.

The plan of feeding was somewhat as follows: A clean, wide board was placed near the hover, on which was scattered a chick food, either Purina or Model. On the board was also a fountain of water. This food was kept in constant supply for about three days, and the chicks were confined close to the hover; thus we did not risk any chance of them straying away in a corner and becoming chilled. About the fourth day the chick food was scattered in cut hay so as to get the chicks to work, the



Fig. 3.—Growing Chickens in the Cornfield.

run near the hover being gradually enlarged day by day. They nearly always took to this kindly. We now ceased feeding the chick food from the board, but placed a trough of dry mash before them for an hour, two or three times a day. This mash was composed of bran, shorts, oatmeal, cornmeal and beef scrap of equal parts by measure, with the exception of the cornmeal, of which we use double the quantity of any other food. We aimed to give the chicks from the start all the green food they would eat, consisting of lettuce and sprouted grains. The former was grown especially for the late hatched chicks, and what was fed the earlier ones was largely refuse from the garden. I believe it would pay most poultrymen to grow a little lettuce for the young chicks. When the chicks reached

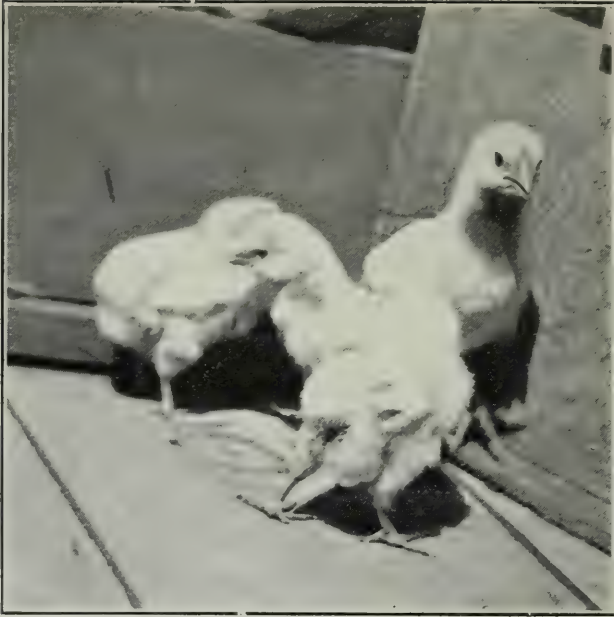


Fig. 4. — White Wyandotte chicks at about two weeks of age. A healthy chick at the back, and three white diarrhoea chicks at the front.



Fig. 5.—Apparatus and methods of studying Natural Incubation.

an age of three weeks, wheat was gradually substituted for the chick food. Nearly all the food from this time on was fed from hoppers, or otherwise kept constantly in front of them.

The April chickens were fed more in the litter because they could not get out of doors as well owing to bad weather.

WHY CERTAIN MATERIALS WERE USED IN THE INCUBATORS.

Early in the winter we were looking for some method by which to increase the carbon dioxide in incubators. The idea was suggested to us that by the use of a species of bacteria which produces large quantities of gas we might be able to get the carbon dioxide in sufficient quantities. We obtained from the Bacteriological Laboratory a culture which would grow readily in milk. This culture was said to be one of the most gassy known. In order to produce the carbon dioxide this culture was mixed with milk and the milk renewed every four days during the period of incubation. We next considered whether sweet milk would be better than sour milk, or whether whole milk would be superior to skim-milk.

We tried operating machines with whole milk, skim-milk, and buttermilk. We have some machines that have been operated where buttermilk was used with the carbon dioxide starter and where buttermilk only has been used.

After making several *post-mortem* examinations of incubator chickens, and noting their peculiar conditions, we were of the opinion that this might be a bacterial disease. Not then having results of all the work done in the Bacteriological Laboratory, we thought it would be a wise precaution to disinfect the incubators. We had two common disinfectants on hand—mercuric chloride and zenoleum. The incubators during the second hatch were washed with a 10 per cent. solution of zenoleum. By this we mean that the inside of the machine, including the tray, the thermometer, the top, the bottom and the sides, were thoroughly scrubbed with this solution. While the machine was still wet, the eggs were placed on the trays and started. Practically the same method was used with the mercuric chloride, with the exception that we endeavored to use it much more freely on the woodwork than upon the metal parts of the machine. No other disinfectants have been tried. Possibly other carbolic or creosote compounds would give equally as good or even better results. We have not had the machines, nor the time, this year to branch out from this one line. Theoretically, several other compounds should be as good. One of our co-operative experimenters reports excellent results on the use of Jeyes' Fluid, and a friend says he got good results from creolin. These trials are the outcome of a knowledge of our unpublished results. When visiting poultry plants a few years ago, the writer, along with L. H. Baldwin, of Toronto, and F. C. Elford, of Macdonald College, were led to believe from observation that a strong odor of lamp fumes in an incubator room was likely to produce a chick low in vitality. A test or two was made at this College with dry machines operated in small rooms, and

the results appeared to point to a weakness in chicks so hatched. I was never satisfied with these tests, and this year having machines from which the lamp fumes could be piped direct from the lamp of one machine to the intake of any other, we thought it wise to try and see what the result would be. We possibly lost a portion of the fumes and no doubt introduced some air from the room, but we did succeed in introducing sufficient lamp smoke to turn white eggs about the color of smoked ham, and the machine had a strong odor of lamp smoke. Needless for me to say that the results so far are a surprise.

GENERAL SYMPTOMS OF WHAT IS COMMONLY CALLED WHITE DIARRHŒA IN YOUNG CHICKS.

When chicks are about twenty-four to ninety-six hours old, they resemble one another very much in appearance, with the exception that we have noticed that hen-hatched chickens and chickens hatched in moist incubators were longer in the down or looked larger and fluffier. The trouble generally begins about the fifth day. Some of the chicks will have a thin, white discharge from the vent; the chick is not active, it has a sleepy look, and the head appears to settle back towards the body. One would think the chick was cold or in great pain. Some of the chickens get in the warmest spot under the hover; others have intense thirst. The white discharge from the vent is not always present. The chicks may die in large numbers between the fifth and tenth days, or there may be a gradual dropping off each day until they are perhaps six weeks of age. The disease kills some quickly; others linger for a week or more. A few chicks appear to recover, but seldom, if ever, make good birds; they are small, unthrifty, and are good subjects for roup or any other epidemic to which chickens are subject.

To the ordinary observer a *post-mortem* examination will reveal the following conditions: The lungs will usually show white spots on them; these are generally seen on the side of the lungs next to the ribs. The white spots are generally quite hard and cheesy. These spots are not always present, but from our examinations I would judge they are in fifty per cent. of the cases. I have seen these in chicks on every poultry farm that use incubators where I have been this year. Some lungs have no white spots, but are red, sometimes fleshy. These, in our experience, are not very common unless the chickens get chilled.

The yolk is often hard and cheesy. It varies greatly; some yolks are of a gelatinous nature or almost like the white of the eggs; others are hard and cheesy and very yellow in color, and sometimes are greatly inflamed; other yolks appear like a custard that has curdled, and these have usually a very offensive odor. The cæca, or blind intestine, is frequently filled with a cheesy substance.

We have written notes on 463 *post-mortems* held between April and August, 1907. It may be interesting to know what are the general con-

ditions as found in these chicks. If we tabulate the results as to the common condition found—*i.e.*, cheesy spots in the lungs, non-absorbed yolks and hardened or cheesy accumulations in the cæca—we found 207 chicks had cheesy spots in their lungs, 138 had hardened yolks, and 113 had abnormal cæca. Again, if we take a combination of the conditions found where the lungs, yolk, and cæca are abnormal, we find 102 in this class; where the lungs and yolk are diseased there are 164.

NOTES ON TABLE III.—HENS VS. INCUBATORS.

958 eggs were set in the machines, and 436 chicks were hatched, or 45.5 per cent. of the eggs set.

335 eggs were set under hens, and 196 chicks hatched, or 58.5 per cent. of the eggs set.

As the same hens' eggs were used in each method the hen has the advantage, and had she not been in cramped quarters for a portion of the hatches her hatches would have been larger.

It will be noticed that the mortality of the chicks hatched on May 11th was very high. I think that the mortality was not, entirely, due to incubation. With this hatch, we decided to mark and weigh each chick from each egg. To do this we used pedigree trays of our own design. Each hen's eggs on the nineteenth day of incubation were placed in a separate compartment, and the tray put in a machine. This, of course, makes all but one egg from each hen finished in a machine. With this particular machine we ran the temperature very high, and kept it there until the chicks were over 24 hours old. These chicks panted very much. They began dying about the usual time, and had the usual symptoms. My personal opinion is that if the chicks pant very much in a machine, they are likely to have a heavy death rate.

Pedigree and weight records were not kept of the April chicks, but were of all others with the exception of the hatch of May 6th. Where the mortality of the chicks hatched by machines, as given in the above table, is different from that given for the entire machine in another table, the mortality here given applies *only* to the chicks from the eggs laid by the same hens as those set under hens.

Hen-hatched chickens from eggs set July 18th suffered somewhat from leg weakness. More mortality was due to this than any other cause. The chickens were reared in a very small run, and were fed all they would eat, or food was in front of them at all times. Had these chickens been reared in an open field this difficulty might have been overcome. The mortality of the chicks from machine No. 2 was practically all from the common cause, bowel trouble, etc. The hens that were set in the incubator hatched chickens on the average low in vitality, several of them showing the usual symptoms of white diarrhœa. We have never hatched such chickens, in any year, from hens setting on earth.

From what I observed of the chicks, those hatched from hens setting on moist earth grew the best.

NOTES ON TABLE IV.—MOISTURE MACHINES VS. DRY MACHINES.

The results from the 1907 Prairie State machines leave no room for doubt that moisture increases the hatch and the vitality also.

In nearly every other make the results practically point in the same direction. With the 1905 Cyphers the results are not very different, but I would like to try moisture earlier in the season, and in parallel hatches, as was done with the Prairie State machines.

With Prairie State machines, it will be noticed that the moisture machine has less fully formed dead chicks in the shell, it hatches more chickens, a higher per cent. of the fertile eggs, as well as a higher per cent. of the total eggs set.

There is a difference of 10.9 per cent. of the eggs set, or 13.1 per cent. of the fertile eggs in favor of the use of moisture.

If a comparison be made between the two methods of operating as to the percentage of live chicks to the eggs set, we find that all the moist machines average 35.9, or if we eliminate those in which the tarry compound was used we have an average of 32.3, whereas all the dry machines give but 13.4, or eliminating the one in which the tarry compound was used they then average 12.1, or, in other words, 100 eggs hatched in the machine when operated without moisture gave us 12.1 chicks alive at four weeks of age, and 100 eggs hatched in the machine with moisture gave us 30.3 chicks alive at four weeks of age.

Buttermilk used in the moisture pan beneath the eggs appears to add vigor to the chicks. The buttermilk was changed every four or five days in nearly all machines. I cannot account for the heavy mortality in the 1905 Cyphers set May 30th.

With the Cortland incubator, through some accident, the lamp went out. The incubator room had several windows open and a gust of wind may have blown out the lamp. The chicks in this hatch I think were chilled. Buttermilk gives sufficient moisture in nearly all instances to keep the evaporation nearly equal to that of a hen.

Whole milk supplied the moisture but did not increase the hatch or the vitality of the chicks.

When zenoleum was used the vitality was very good.

As compared with buttermilk, one is led to believe that the acid of the buttermilk has some action on the shell or contents, hence a chick higher in vitality is produced.

NOTES ON TABLE V.—MACHINES WASHED WITH A TEN PER CENT. SOLUTION OF ZENOLEUM.

This substance evidently has some beneficial action, the exact nature of which we do not know. The highest mortality, also the lowest, are from dry machines. I would use this substance in every machine set, in preference to anything we have used to date. It has worked satisfactorily on one large poultry farm in New York State.

NOTES ON TABLE VI.—MACHINES IN WHICH LAMP FUMES AND CARBON DIOXIDE WERE USED.

The lamp fumes appear to do no harm from a vitality standpoint, but rather increases vigor.

Lamp fumes do not increase the hatch, but decrease it. I would like to test lamp fumes on many makes of machines at all seasons of the year before venturing to say that they are beneficial.

We had hoped to show better results from the use of carbon dioxide, and I do not consider the result so far as being at all final. We have not yet, to my mind, secured the proper method of application.

Thus far it appears to be a factor in vitality more than in decreasing the fully formed chicks dead in the shell.

THE MODEL INCUBATOR.

The heaviest mortality was from chicks hatched from the eggs set in March. The machine was run dry, and the evaporation was the largest of the season.

Washing the machine with a ten per cent. solution of zenoleum appears to reduce the mortality or increase the vitality. The hatches where the moisture was used are higher than where little or no moisture was used. It is also evident that a large surface of water requires to be exposed in order to check evaporation.

With the hatch of June 24th, the evaporation was not as great as early in the season, owing, I believe, to the interior of the machines being practically saturated with moisture gathered from previous hatches when moisture was used.

Buttermilk used as moisture produces fairly good chickens.

With this machine, as with others, some condition was present late in the season that was absent early in the season, which increased the vigor of the chicks.

CYPHERS INCUBATORS.

I have no suggestions or reasons to offer as to why the 1905 machine gave much better results than the 1906 design.

The 1906 hatched better when moisture was used. The method of applying the zenoleum was purely experimental, and led us to believe that zenoleum required to be applied thoroughly before the eggs were put in.

The chicks from the 1905 machine, when it was washed with zenoleum, were good, thrifty birds.

The use of buttermilk in this machine, so far, is not as satisfactory, especially from the vitality view.

THE PEERLESS INCUBATOR.

The introduction of moisture in this machine appears to have been beneficial, there being a higher hatch and fewer fully formed chicks dead in the shell from the eggs set May 11th than from another hatch. The hatch following the one in which moisture was freely used, the evaporation is not as great as in those ran earlier in the season. This, I believe, is due, as in the case of the Model Incubator, to the absorption of water by the interior surface of the hatching chamber and the evaporation of the same in the hatch following.

When the machine was washed with zenoleum the chicks were good healthy fellows.

Buttermilk used as moisture gave very good results.

The vitality was lowest early in the season.

I have no comments to make on any of the machines on this table except the Hearson. The others have not been used a sufficient length of time, and the results so far are very plain in the table.

The Hearson has some up-draft ventilation—not unlike a hen. This may account for its hatching better chickens on the average than any other make.

The use of buttermilk appeared to help the vitality when the machine gave evidence of hatching inferior chicks.

Moisture was used in all hatches, so we cannot say what it would do if run dry.

No record is given of the Chatham incubator. These machines were used largely in the 1906 experiments, and to a somewhat limited extent during the 1907 experiments. They usually worked well as compared to other makes.

TABLE I.—INCUBATOR SERIES No. I. (Machines Nos. 1, 2, 3 and 4 are 1907 Prairie State Incubators.)

Machine.	Date set.	No. of eggs set.	No. of eggs infertile.	No. of fully formed chicks dead in shell.	Hatched.	Percentage hatched of total eggs set.	Percentage hatched of fertile eggs.	Average evaporation of the eggs set.	of chicks dead at four weeks of age.	Remarks.
No. 1...	March 10	†134	17	21	50	37.3	42.7	15.2	*67.4	No moisture used.
" 3...	" 10	†139	17	17	57	41.0	46.7	9.2	*16	Skim-milk used for moisture; milk was either sweet or sour.
" 4...	" 10	†132	24	11	66	50.0	61.1	8.4	*15	Water used for moisture.
Hearson	April 3	56	3	8	29	51.7	54.7	12.8	26	Water used for moisture.
No. 1...	" 3	97	10	15	52	53.6	59.7	15.8	100	No moisture used.
" 2...	" 3	97	11	9	53	54.6	61	10.5	57.5	Whole milk used for moisture.
" 3...	" 3	97	11	9	58	59.7	67.4	12.0	22.79	Butter milk used for moisture.
" 4...	" 3	97	14	7	63	64.9+	75.9	10.8	67.2	Water used for moisture.
Hearson	" 26	48	6	10	27	56.25	64.3—	13.5	11	Water used in moisture pan.
No. 1...	" 26	71	10	7	45	63.3+	73.7	10.9	55	These machines } Water used as moisture.
" 2...	" 26	71	11	7	35	49.3—	58.3	13.9	79	were washed with } No moisture used.
" 3...	" 26	71	13	5	39	54.9+	67.2+	10.6	55	mercuric chloride } Whole milk used for moisture.
" 4...	" 26	71	16	8	35	49.3—	63.6	10.1	13	before being set. } Butter milk used for moisture.
Hearson	May' 21	38	5	3	25	65.7+	75.7	10.9	59.3	Water used for moisture.
Mo. 1..	" 21	61	13	9	21	34.4	43.7	9.4	23.5	These machines } { Water used for moisture, also lamp
" 2..	" 21	61	8	9	38	62.2+	71.7	9.4	25.6	were washed with } { fumes used in hatching chamber.
" 3..	" 21	61	3	8	36	59	62	10	26.6	a ten per cent. } { Water used for moisture.
" 4..	" 21	61	8	9	37	60.6	69.8	16.6	28.8	solution of } { Artificial carbon dioxide and water.
Climax..	" 21	61	7	6	42	68.8	77.7+	10.4	21.4	zenoleum. } { No moisture used.
Chath'm	" 21	61	5	12	30	49.1+	53.5	12.2	8.0	Water used for moisture.
Hearson	June 17	19	2	5	9	47.4	52.9	9.6	14.3	Washed with zenoleum. Butter milk used for moisture.
Mo. 1.	" 17	44	5	8	24	54.5+	61.5+	11.9	17.6	Butter milk used for moisture.
" 2..	" 17	44	6	3	26	59	68.4+	8.5	15	Lamp fumes in hatching chamber—no moisture used.
" 3..	" 17	44	6	5	23	52.2+	60.5+	8.3	13	Washed with zenoleum—whole milk used for moisture.
" 4..	" 17	44	2	5	24	54.5+	57.1+	9.3	25	{ Washed with zenoleum, artificial carbon dioxide used,
Climax.	" 17	44	4	11	24	54.5+	60	12.8	25.5+	{ also water for moisture.
Mac. 1..	July 18	68	22	8	19	28.0	43.5	14.7	16.1	{ Washed with zenoleum and a 5 per cent solution of
" 2..	" 18	68	23	10	22	32.3	48.9	14.5	38.5	zenoleum used for moisture.
" 3..	" 18	68	23	2	26	38.2	57.8	9.7	15	No moisture used.
" 4..	" 18	68	18	5	31	45.6	62.0	10.1	12.9	Artificial carbon dioxide and water used.
Model...	" 18	68	19	3	32	47.0	65.3	8.3	18.7	Washed with zenoleum—Water used for moisture.
										Butter milk used for moisture.

*Mortality or two weeks only.

† The eggs used in these machines were laid by the same hen, but not all; in all other machines the same hen's egg is in each machine.† One egg broken.

TABLE II.—INCUBATOR SERIES No. II.

Machine.	Date set.	No. of eggs set.	No. of eggs infertile.	No. of fully formed chicks dead in shell.	Hatched.	Percentage hatched of total eggs set.	Percentage hatched of fertile eggs.	Average evaporation of the eggs set.	% of chicks dead at four weeks of age.	Remarks.
1905 Cyphers.	March 18	127	11	23	64	50 +	55.1	16.8	3 weeks only	No moisture used.
Open Bottom	"	114	15	21	33	28.9 +	33.3	13.2	"	2 pans of milk used beneath the egg tray, each pan was 12 in. × 6 in. × 2 in. deep.
Prairie State.	"	105	8	13	55	52.3 +	56.7	15.7	"	A small pan of water used beneath the egg tray.
Model.....	"	103	10	16	52	50.5	55.7—	13.8	"	All the machines set this date (April 11) were washed with a ten per cent. solution of zenoleum before setting.
Chatham	"	103	10	16	52	50.5	55.7—	13.8	"	No moisture used.
1905 Cyphers..	April 11	83	6	9	47	56.6	61 +	14.7	7.4	A little water used for moisture.
Open Bottom	"	83	10	12	27	32.5	37 —	12.6	15.3	The bottom of the machine was dampened
Prairie State.	"	83	10	11	44	53.3	60 +	12.3	10	several times daily with tepid water.
Model	"	83	10	11	44	53.3	60 +	12.3	10	No moisture used.
1905 Cyphers.	May	108	18	12	57	52.7 +	63.3	17.6	38	
Open Bottom	"	108	18	21	41	38 —	45.5 +	11.3	41.6	Small pan of milk used in both the top and bottom of the machine.
Prairie State.	"	108	25	12	61	56.4	73.4	12.17	45	A pan of water nearly the size of the bottom of the machine was used under the egg tray.
Model	"	108	20	15	45	41.6	58.4	13.2	58.8	Buttermilk used as moisture.
Cortland	May	77	12	8	42	56	64.6	9.2	40	Buttermilk used in a pan beneath the egg tray.
1905 Cyphers.	"	77	13	6	44	57.7	68.7	13.2	29	A pan of skim milk was used in both the top and bottom of the machine.
Open Bottom	"	77	13	5	50	64.8	78.1	10.7	21	The large pan was filled with buttermilk and placed under the eggs.
Prairie State.	"	77	13	5	39	50 +	60	10.7	56	Whole milk used as moisture.
Model	"	77	12	8	32	48.4	61.5	7.0	21.8 +	Buttermilk used as moisture beneath the egg tray.
Cortland	June	66	14	5	32	48.4	61.5	7.0	21.8 +	Whole milk used as moisture.
1905 Cyphers..	"	66	13	8	38	57.5 +	71.7—	9.5	25.3 +	Ran dry—no moisture used.
Open Bottom	"	66	15	6	33	50	64.7 +	13.3	27.5	however, was very moist from water absorbed from previous hatching.
Prairie State.	"	66	15	6	33	50	64.7 +	13.3	27.5	Water used as moisture. This machine was washed with a ten per cent. solution of zenoleum.
Model	"	66	18	5	34	51.5	70.8	9.7	23.2	
Cortland	"	66	18	5	34	51.5	70.8	9.7	23.2	

HENS vs. INCUBATORS.—TABLE III, SERIES III.

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How Hatched.	Date Set.	Number of eggs set.	Number of eggs infertile.	Number of chicks fully formed dead in the shell.	Number of chicks hatched.	Percentage of chicks hatched of the total eggs set.	Percentage of chicks hatched of the fertile eggs.	Average evaporation of the eggs.	Percentage of the chicks dead at four wks. of age.
<i>Incubators.</i>									
1906 Cyphers. No moisture used.....	Mar. 23	233	36	37	62	26.6	31.4	15.3	75
Peerless. No moisture used	"	198	31	21	71	35.9—	42.5	15.8	90
1906 Cyphers. Pans of water used large enough to cover nearly one-half of the bottom of the machine	April 16	120	19	14	48	40	47.5	11.3	56.2
Peerless. No moisture used	"	120	19	11	54	45	53.4	15.8	44.4
1906 Cyphers. No moisture used, but the machine was sprinkled with a solution of zenoleum on the 3rd and 6th days of incubation	May 11.....	183	29	27	71	38.8	46.1	14.2	50.0
Peerless. Pans of buttermilk used in the bottom of the machine.....	"	183	26	6	116	63.3	73.9	9.1	*27.2
Chatham. Pans of milk used in the bottom of the machine	"	93	12	11	58	62.4	71.6	9.1	*27.2
Continuous. Some moisture used.....	June 11	142	16	16	73	51.4	58.0	12.2	9.6
Peerless. Washed with a ten per cent. solution of zenoleum.....	"	142	19	13	74	52.1	60.2	10.6	12.2
Continuous. Some moisture used.....	July 5	140	23	15	48	34.3	41.0	14.4	14.5
Peerless. No moisture used	"	141	34	14	48	34.1	44.9	14.0	52.1
1907 Prairie State. Moisture pan of water ...	April 26	12	1	....	11	91.6	100	10.9	See table No. 1.

* A mistake was made in marking these chicks, both machines having the same marks.

How Hatched.	Date Set.	Number of eggs set.	Number of eggs infertile.	Number of chicks fully formed dead in the shell.	Number of chicks hatched.	Percentage hatched of the total eggs set.	Percentage of the fertile eggs.	Average evaporation of the eggs.	Percentage of the chicks dead at 4 wks. of age.
1907 Prairie State. No moisture used.....	April 26.....	12	2	2	7	58.3	70	13.9	See table No. 1.
1907 Prairie State. Whole milk used in moisture pan.....	April 26.....	12	1	1	9	75.	81.8	10.6	"
1907 Prairie State. Butter-milk used in the moisture pan	April 26.....	12	1	1	10	83.3	90.9	10.1	"
Hearson Incubator. Water used in moisture pan ..	April 26.....	12	..	2	9	75	75	13.5	"
Hen set in wire nest; the nest raised about one foot from the floor of the incubator room	April 26.....	12	..	1	10	83.3	83.3	14.1	} 16.66
Hen set on four inches of earth in a box in the incubator room.....	April 26.....	12	1	....	11	91.6	100	11.9	
Hen set on four inches of earth in a box in the incubator room.....	April 26.....	12	1	1	10	83.3	90.9	13.2	
1907 Prairie State. Water used in moisture pan	April 3.....	9	1	1	4	44.4	50	10.8	See table No. 1.
1907 Prairie State. No moisture used	April 3.....	9	1	1	3	33.3	37.5	15.8	
1907 Prairie State. Whole milk used in moisture pan.....	April 3.....	9	2	....	6	66.6	85.7	10.5	
1907 Prairie State. Buttermilk used in moisture pan.....	April 3.....	9	1	1	5	55.5	62.5	12	

Hearson Incubator. Water used in moisture pan	April 3	9	1	1	5	55.5	62.5	12.8	} 16.66
Hen set in wire nest; the nest raised about one foot from the floor of the incubator room	April 3	9	1	....	6	66.6	75	14.2	
Hen set on four inches of earth in a box in the incubator room.....	April 3	9	2	1	5	55.5	71.4	10.6	
1905 Cyphers. No moisture used	May 6	108	18	12	57	52.7	63.3	17.6	38
Open Bottom Prairie State. Milk used for moisture.....	May 6	108	18	21	41	38	45.5	11.3	41.6
Model. Moisture pan of water used in the bottom of machine, moisture pan was practically the full size of machine bottom	May 6	108	25	12	61	56.4	73.4	12.17	45
Cortland. Moisture pan filled with buttermilk	May 6	108	20	15	45	41.6	58.4	13.2	58.8
Hens set in rows of boxes in a colony house very little earth used in the nest	May 6	108	18	5	62	57.4	68.8	12.2	9.7
Mach. No. 1. Lamp fumes dry.....	July 18	68	22	8	19	28.0	43.5	14.7	16.1
Mach. No. 2. Dry, no moisture	July 18	68	23	10	22	32.3	48.9	14.5	38.5
Mach. No. 3. Artificial CO ₂ , moisture pan...	July 18	68	23	2	26	38.2	57.8	9.7	15
Mach. No. 4. Zenoleum and moisture pan...	July 18	68	18	5	31	45.5	62.0	10.1	12.9
Model. Buttermilk in pan.....	July 18	68	19	3	32	47.0	65.3	8.3	18.7
Hens, set in trap nests, in pens Nos. 6 and 7. Some earth in each nest.....	July 18	68	10	2	26	38.2	44.8	11.3	20
The Continuous Hatcher. Moisture supplied by small tank on outside of machine ..	July 5	11	1	2	4	36.3	40	14.4	75
Peerless Incubator. No moisture used	July 5	11	1	3	2	18	20	14.0	50

HENS VS. INCUBATORS.—TABLE III, SERIES III.—Concluded.

How Hatched.	Date Set.	Number of eggs set.	Number of eggs infertile.	Number of chicks fully formed dead in the shell.	Number of chicks hatched.	Percentage hatched of the total eggs set.	Percentage hatched of the fertile eggs.	Average evaporation of the eggs.	Percentage of the chicks dead at 4 wks. of age.
Hen sitting on four inches of earth in box in incubator room	July 5.....	11	1	....	8	72.7	80	9.9	12.5
Hen sitting in box in incubator room, no earth in nest	July 5.....	11	1	....	8	72.7	80	12.9	12.5
Hen sitting in an open bottom incubator, under the eggs was the egg tray and two thickness of burlap that is used in such machines	July 5.....	11	1	....	8	72.7	80	14.78	37.5
Continuous Hatcher. Moisture supplied by small tank on outside of machine.....	June 11	12	2	1	4	33.3	40	12.2	25
Peerless Incubator. No moisture used, washed with 10 per cent. solution of zenoleum before eggs were put in.	June 11	12	2	1	6	50	60	10.6	16.6
Hen sitting on earth nest in incubator room ..	June 11	12	2	1	6	50	60	9.7	16.6
Hen sitting in box in incubator room, no earth in nest	June 11	12	*	2	4	33	36.3	8.9	25
Hen sitting in incubator	June 11	12	2	3	6	50	60	14.3	33
1906 Cyphers Incubator. No moisture used..	May 11	12	..	2	5	41.6	41.6	14.2	100
Peerless Incubator. Moisture was supplied by two pans buttermilk; pans were full width of machine, by 1 foot wide and 2 inch deep	May 11	12	1	1	7	58.3	63.6	9.1	100
Chatham. Moisture pan used in bottom of machine.....	May 11	11	2	1	5	45.4	55.5	9.9	80
Hen on earth nest in incubator room.....	May 11	12	3	....	9	75.	100	9.5	
Hen in box in incubator room, no earth in nest ..	May 11	12	..	....	12	100	100	13.5	
Hen sitting in incubator.....	May 11	12	1	2	9	75	81.8	14.7	

* 1 infertile. 2 eggs broken 1st week.

TABLE NO. IV.—MOISTURE VS. DRY MACHINES.

1907 Prairie State.	Date Set.	Number of Eggs Set.	Number of Infertile Eggs.	Number of fully formed Chicks dead in Shell.	Number of Chicks Hatched.	Percentage Hatched of Total Set.	Fertile Eggs.	Average Evaporation of the Eggs.	Percentage of Chicks dead at four weeks of age.	Percentage of Chicks alive at four weeks of age to the total eggs set.
<i>Water Used in Moisture Pan.</i>										
Machine No. 4.....	Mar. 10	132	24	11	66	50	61.1	8.4	15	42.5
" " 4.....	Apr. 3	97	14	7	63	64.3	75.9	10.8	67.2	21.3
" " 1.....	Apr. 26	71	10	7	45	63.3	73.7	10.9	55	28.5
* " 2.....	May 21	61	8	9	38	62.2	71.7	9.4	25.6	46.3
* " 4.....	June 17	44	2	5	24	54.5	57.1	9.3	25.5	40.6
* " 4.....	July 18	68	18	5	31	45.6	62.0	10.1	12.9	39.7
Totals		473	76	44	267	56.3	67.2	9.8		
<i>No Moisture Used.</i>										
Machine No 1.....	Mar. 10	134	17	21	50	37.3	42.7	15.2	67.4	12.2
" " 1.....	Apr. 3	97	10	15	52	53.6	59.7	15.8	100	.....
" " 2.....	Apr. 26	71	11	7	35	49.3	58.3	13.9	79	10.4
* " 4.....	May 21	61	8	9	37	60.6	69.8	16.6	28.8	43.1
" " 2.....	July 18	68	23	10	22	32.3	48.9	14.5	38.5	19.9
Totals		431	69	62	196	45.4	54.1	15.2		
<i>Machines in which Buttermilk was used in the Moisture Pan.</i>										
No. 3 Prairie State.....	Apr. 3	97	11	9	58	59.7	67.4	12	22.79	46.1
No. 4 Prairie State.....	Apr. 26	71	16	8	35	49.3	63.6	10.1	13	46.2

TABLE No. IV. —MOISTURE VS. DRY MACHINES. —Concluded.

1907 Prairie State.	Date Set.	Number of Eggs Set.	Number of Infertile Eggs.	Number of fully formed Chicks dead in Shell.	Number of Chicks Hatched.	Percentage Hatched of Total Set.	Percentage Hatched of Fertile Eggs.	Average Evaporation of the Eggs.	Percentage of Chicks dead at four weeks of age.	Percentage of Chicks alive at four weeks of age to the Total Eggs Set.
<i>Machines in which Buttermilk was used in the Moisture Pan.</i>										
Hearson.....	June 17	19	2	5	9	47.4	52.9	9.6	14.3	40.6
Peerless.....	May 11	183	26	6	116	63.3	73.9	9.1	27.2	45.6
Chatham.....	May 11	93	12	11	58	62.4	71.6	9.1	27.2	45.6
†Cortland.....	May 6	108	20	15	45	41.6	58.4	13.2	58.8	17.2
1905 Cyphers.....	May 30	77	12	8	42	56	64.6	9.2	40	33.6
Model.....	May 30	77	13	5	50	64.8	78.1	10.7	21	51.2
1905 Cyphers.....	June 24	66	14	5	32	48.4	61.5	7	21.8	37.8
Model.....	July 18	68	19	3	32	47	65.3	8.3	18.7	38.2
<i>Machines in which whole Milk was used in the Moisture Pans.</i>										
No. 2, 1907 Prairie State.....	Apr. 3	97	11	9	53	54.6	61	10.5	57.5	23.2
No. 3, 1907 Prairie State.....	Apr. 26	71	13	6	39	54.9	67.2	10.6	55	24.7
*No. 2, 1907 Prairie State.....	June 17	44	6	3	26	59	68.4	8.5	15+	50.2
Cortland.....	May 30	77	12	8	39	50	60	10.7	56	22

*These machines were washed with a 10% solution of zenoleum.

†Lamp went out when chicks were hatching.

TABLE NO. V.—INCUBATOR WASHED WITH TEN PER CENT. SOLUTION OF ZENOLEUM.

Name of Machine.	Date Set.	Number of Eggs Set.	Number of Infertile Eggs.	Number of fully formed Chicks dead in Shell.	Number of Chicks Hatched.	Percentage Hatched of Total Eggs Set.	Percentage Hatched of Fertile Eggs.	Average Evaporation of the Eggs.	Percentage of Chicks dead at four weeks of age.	Percentage of Chicks alive at four weeks of age to the total eggs set.	Remarks.
1905 Cyphers	Apr. 11	83	6	9	47	56.6	61	14.7	7.4	52.4	Run dry.
Open Bottom Prairie State.	Apr. 11	83	10	12	27	32.5	37	12.6	15.3	27.5	Some milk and water used.
Model.....	Apr. 11	83	10	11	44	53.3	60	12.3	10	48	Some milk and water used.
Cortland.....	June 24	66	18	5	34	51.5	70.8	9.7	23.2	39.6	Moisture used.
Open Bottom Prairie State.	June 24	66	13	8	38	57.5	71.7	9.5	25.3	42.9	Whole milk used for moisture.
No. 1, 1907 Prairie State...	May 21	61	13	9	21	34.4	43.7	9.4	23.5	26.4	Lamp fume-water used for moisture.
No. 2, 1907 Prairie State...	May 21	61	8	9	38	62.2	71.7	9.4	25.6	46.3	Water used for moisture.
No. 4, 1907 " " "	May 21	61	8	9	37	60.6	69.8	16.6	28.8	43.1	Dry.
No. 2, 1907 " " "	June 17	44	6	3	26	59	68.4	8.5	15	50.2	Whole milk for moisture.
No. 3, 1907 " " "	June 17	44	6	5	23	52.2	60.5	8.3	13	45.4	Carbon dioxide, also water, for moisture.
No. 4, 1907 " " "	June 17	44	2	5	24	54.5	57.1	9.3	25.5	40.6	5 per cent. zenoleum used in water for moisture.
No. 4, 1907 " " "	July 18	68	18	5	31	45.6	62.0	10.1	12.9	39.7	Water used for moisture.
Chatham	May 21	61	5	12	30	49.1	53.5	12.2	8.0	45.9	Buttermilk for moisture.
Peerless	June 11	142	19	13	74	52.1	60.2	10.6	12.2	45.7	Dry.

TABLE VI.

How operated.	Date set.	No. of eggs set.	No. of infertile eggs.	No. of fully formed chicks in shell.	No. of chicks hatched.	Percentage hatched of total eggs set.	Percentage of hatched of fertile eggs.	Average evaporation of the eggs.	Percentage of chicks dead at 4 weeks of age.	Percentage of chicks alive at 4 weeks of age to the total eggs set.
<i>Machines into which the lamp fumes were forced.</i>										
No. 1. Moisture used . .	May 21	61	13	9	21	34.4	43.7	9.4	23.5	26.2
" 1. " " . .	June 17	44	5	8	24	54.5	61.5	11.9	17.6	44.9
" 1. " " . .	July 18	68	22	8	19	28.	43.5	14.7	16.1	23.9
<i>Machines in which carbon dioxide was used.</i>										
No. 3. Moisture used . .	May 21	61	3	8	36	59. +	62. +	10.	26.6	43.3
" 3. " " . .	June 17	44	6	5	23	52.2	60.5	8.3	13	45.4
" 3. " " . .	July 18	68	23	2	26	38.2	57.8	9.7	15.	32.5
<i>The Model Incubator.</i>										
One small pan of water was used under the egg tray.	Mar. 18	105	8	13	55	52.3+	56.7	15.7	75.	13.1
*The bottom of the machine was wet with tepid water several times daily sufficient to keep cloths wet... A large pan of water about 1 in. deep covered practically the entire space below the egg tray.... The large pan was filled with buttermilk and used beneath the tray as in the previous hatch.....	April 11	83	10	11	44	53.3	60.	12.3	10.	48.0
	May 6	108	25	12	61	56.4	73.4	12.17	45.	31.
	May 30	77	13	5	50	64.8	78.1	10.7	10.7	51.2

No moisture used..... The large pan was filled with buttermilk and used beneath the egg tray	June 24	66	15	6	33	50.	64.7	13.3	27.5	36.3
<i>1906 Cyphers Incubator.</i> <i>240 egg capacity.</i>										
No moisture used..... Bottom of machine was dampened with zenoleum on the third and sixth days of incubation.....	July 18	68	19	3	32	47.	65.3	8.3	18.7	38.2
Two pans of moisture in the bottom of machine. Pans would cover about one half of the bottom.....	Mar. 23	233	36	37	62	26.6	31.4	15.3	75.	6.6
	May 11	183	29	27	71	38.8	46.1	14.2	50.	19.4
	April 16	120	19	14	48	40.	47.5	11.3	56.2	17.5
<i>1905 Cyphers Incubator.</i> <i>120 egg capacity.</i>										
No moisture used.....	Mar. 18	127	11	23	64	50. +	55.1	16.8	46.	27.
†No moisture used....	April 11	83	6	9	47	56.6	61.	14.7	7.4	52.4
No moisture used.....	May 6	108	18	12	57	52.7	63.3	17.6	38.	32.7
A pan of buttermilk with starter used under the egg tray.	May 30	77	12	8	42	56.	64.6	9.2	40	33.6
A pan of buttermilk was used.....	June 24	66	14	5	32	48.4	61.5	7.	21.8	37.8
<i>Peerless Incubator.</i>										
No moisture used.....	Mar. 23	198	31	21	71	35.9	42.5	15.8	90.	3.6
No moisture used.....	April 16	120	19	11	54	45.	53.4	15.8	44.4	25.0
No moisture used.....	July 5	141	34	14	48	34.1	44.9	14.0	52.1	16.3
*No moisture used....	June 11	142	19	13	74	52.1	60.2	10.6	12.2	45.7
Pan of buttermilk covering nearly three- fourths of the surface under the eggs	May 11	183	26	6	116	63.3	73.9	9.1	27.2	45.6

*Washed with a ten per cent. solution of zenoleum.

†Washed with zenoleum.

TABLE VI.—Continued.

How operated.	Date set.	No. of eggs set.	No. of infertile eggs.	No. of fully formed chicks in shell.	No. of chicks hatched.	Percentage hatched of total eggs set.	Percentage hatched of fertile eggs.	Average evaporation of the eggs.	Percentage of chicks dead at 4 weeks of age.	Percentage of chicks alive at 4 weeks of age to the total eggs set.
<i>The Climax Incubator.</i>										
Moisture used in bottom of machine	May 21	61	7	6	42	68.8	77.7	10.4	21.4	54.
No moisture used	June 17	44	4	11	24	54.5	60.	12.8	25.	40.9
<i>The Cortland Incubator.</i>										
†Moisture pan filled with buttermilk	May 6	108	20	15	45	41.6	58.4	13.2	58.8	17.2
Moisture pan filled with whole milk	May 30	77	12	8	39	50.	60.	10.7	56.	22.
†Water used in moisture pan	June 24	66	18	5	34	51.5	70.8	9.7	23.2	39.6
<i>The Continuous Hatcher</i>										
A little moisture used.	June 11	142	16	16	73	51.4	58.0	12.2	9.6	46.5
A little moisture used.	July 5	140	23	15	48	34.3	41.	14.4	14.5	29.3
<i>The Hearson Incubator.</i>										
Moisture used	April 26	48	6	10	27	56.25	64.3	13.5	11.	50.
Moisture used	May 21	38	5	3	25	65.7	75.7	10.9	59.3	26.7
Buttermilk used as moisture	June 17	19	2	5	9	47.4	52.9	9.6	14.3	40.6
Moisture used	April 3	56	3	8	29	51.7	54.7	12.8	26.	38.3

† Lamp went out when hatching from unknown cause.

Eggs were cold—chicks chilled.

† Washed with zincleum.

TABLE VII. A COMPARISON OF METHODS OF HATCHING.

How Treated.	No. of eggs set.	Per cent. of infertile eggs.	Per cent. of fully formed dead in shell.	Per cent. hatched of total eggs set.	Per cent. of chicks dead at 4 weeks of age.	Live chicks at 4 weeks in % of the eggs set.	No. of hatches.
HENS.							
Earth nests.....	23	13.1	4.3	60.9	14.3	52.2	2
Straw ".....	23	8.7	8.7	52.2	16.6	43.5	2
Ventilated nests.....	23	13.1	13.1	60.8	35.7	39.1	2
Roomy ".....	123	10.6	7.3	66.6	20.7	52.8	11
Crowded ".....	176	15.9	4.0	50.0	12.5	43.7	16
All Hens.....	299	13.7	5.4	56.9	16.5	47.5	27
INCUBATORS.							
Buttermilk and zenoleum.....	61	8.2	19.7	49.1	8.0	45.9	1
Whole milk and ".....	110	17.3	10.0	58.2	21.8	45.5	2
Water, carbon dioxide and zenoleum	44	13.6	11.3	52.2	13.0	45.4	1
Water and zenoleum.....	464	16.1	11.4	52.8	16.7	44.0	6
Buttermilk.....	583	18.3	10.0	52.0	28.0	37.4	8
Water and carbon dioxide.....	129	20.1	7.8	48.1	22.5	37.2	2
Water only.....	1,221	13.9	11.3	51.9	37.0	32.7	13
Lamp fumes dry.....	112	24.1	14.3	38.4	16.3	32.1	2
Zenoleum dry.....	327	13.1	13.7	47.4	32.2	32.1	3
Skim-milk.....	330	13.6	13.0	40.6	26.1	30.0	3
Water, milk and zenoleum.....	83	12.0	14.5	32.5	15.3	27.5	1
Lamp fumes, water and zenoleum...	61	21.3	14.7	34.4	23.5	26.2	1
Whole milk.....	353	15.3	12.2	48.7	52.3	23.2	4
Dry or no treatment.....	1,406	16.3	12.6	40.7	60.5	16.1	12

MATTERS IN GENERAL.

The eggs purchased from outside sources, which includes large poultry farms and the ordinary farm flock, did not hatch chickens any better than our own. When our chickens died when hatched in certain incubators, the others died also. We received no eggs from any source that were free or anywhere nearly free of the bowel trouble, etc.

We have not included the eggs from outside source in our tables for hatches, because we failed to get a division of any lot that was uniform as to fertility, etc., and I believe that exact experimental work with incubators can not be done unless the same hens' eggs are used in each machine.

Some tests were made of putting the eggs under hens for one week and then removing them to an incubator to finish hatching. Eggs were also started in incubators for one and two weeks, and then finished under hens. We also took eggs from the machines on the nineteenth day of

incubation, and finished hatching with hens. Where eggs were finished under hens from the nineteenth day of incubation, no improvement was seen in the chickens. This was tried several times from several machines.

Eggs incubated one week under hens and finished by incubators gave fairly good chicks, but eggs started in incubators for a week and finished by the hen show practically no improvement over the eggs hatched for the whole period in the machine.

This work appeared to indicate that the first portion of the hatch is a very critical time, and every care should be given at this period.

TABLE VIII.

Where Hatched.	Artificial Brooding.		Natural Brooding.	
	Number of chicks brooded.	Number of chicks that died.	Number of chicks brooded.	Number of chicks that died.
1905 Cyphers.....	29	6	36	8
Open Bottom Prairie State.....	24	5	5	0
Model	20	7	30	7
Cortland.....	17	7	34	18
Hens	17	0	46	5
Totals.....	107	25	151	38
Percentage dead in two weeks' brooding.....		21.5		25
No. 1, 1907 Prairie State.....	20	2	14	4
" 2, " " "	20	3	20	3
" 3, " " "	22	2	24	4
" 4, " " "	25	3	18	8
Climax	20	3	16	6
Hearson	3	0	11	2
Totals	110	13	103	27
Percentage dead in four weeks' brooding.....		11.8		26.2

Prairie State Brooders used in each test.

Humidity in Relation to Incubation.

By WM. H. DAY, LECTURER IN PHYSICS.

In the preceding portion of this Bulletin Mr. W. R. Graham has outlined many practical experiments that have been carried on by the Poultry department during the seasons of 1906 and 1907. For those who wish to follow this station further in its endeavors to discover the scientific laws that influence incubation, the following pages are written. We are conscious of the fact that our readers may include all classes of persons from the practical poultryman to the advanced scientist. To the former we would say at the outset: It is primarily in your interests that we investigate these problems and publish our results, hence we feel bound in so far as possible to make even the scientific side of our work intelligible to you; and hence we shall endeavor throughout to present scientific methods and truths in popular form and language.

Some time ago a series of circumstances, which need not be related here, led the department of Physics to enter upon a study of the evaporation of water from soil and from plants, and this broadened out into a study of evaporation in general. This in turn involved a study of the moisture of the atmosphere. Now the Latin word for "moist" is *humidus*, hence instead of "moisture of the atmosphere" we may say "humidity." Since we were interested in the subject, Mr. Graham asked us to co-operate with him in a study of the humidity in incubators; for opinion as to the desirability of moisture during incubation was sharply divided, some holding strongly that it was detrimental, that the chicks were often "drowned in the shell," others holding just as firmly the contrary view that moisture was highly beneficial. Before entering in detail into our investigations on the subject it may be well for the sake of our practical readers to give a brief review of the methods by which a knowledge of humidity is gained, believing that such a review will lead to a better understanding of the subject, "Humidity in Relation to Incubation."

DETERMINING THE AMOUNT OF MOISTURE IN THE AIR.

Years ago little was known of the amount of moisture in the air. But as science advanced and the influence of the humidity of the air upon all life was realized, a fuller knowledge of the subject became desirable. It was known that certain acids and salts had a great affinity for water, and so the idea was suggested that if air were drawn through these substances it would be deprived of the water contained in it, the substances gaining in weight by the amount of water absorbed. Investigation proved that two or three drying tubes, in series, were sufficient to absorb *all* the moisture from air being drawn through. Figure No. 1 shows the apparatus evolved for the purpose.

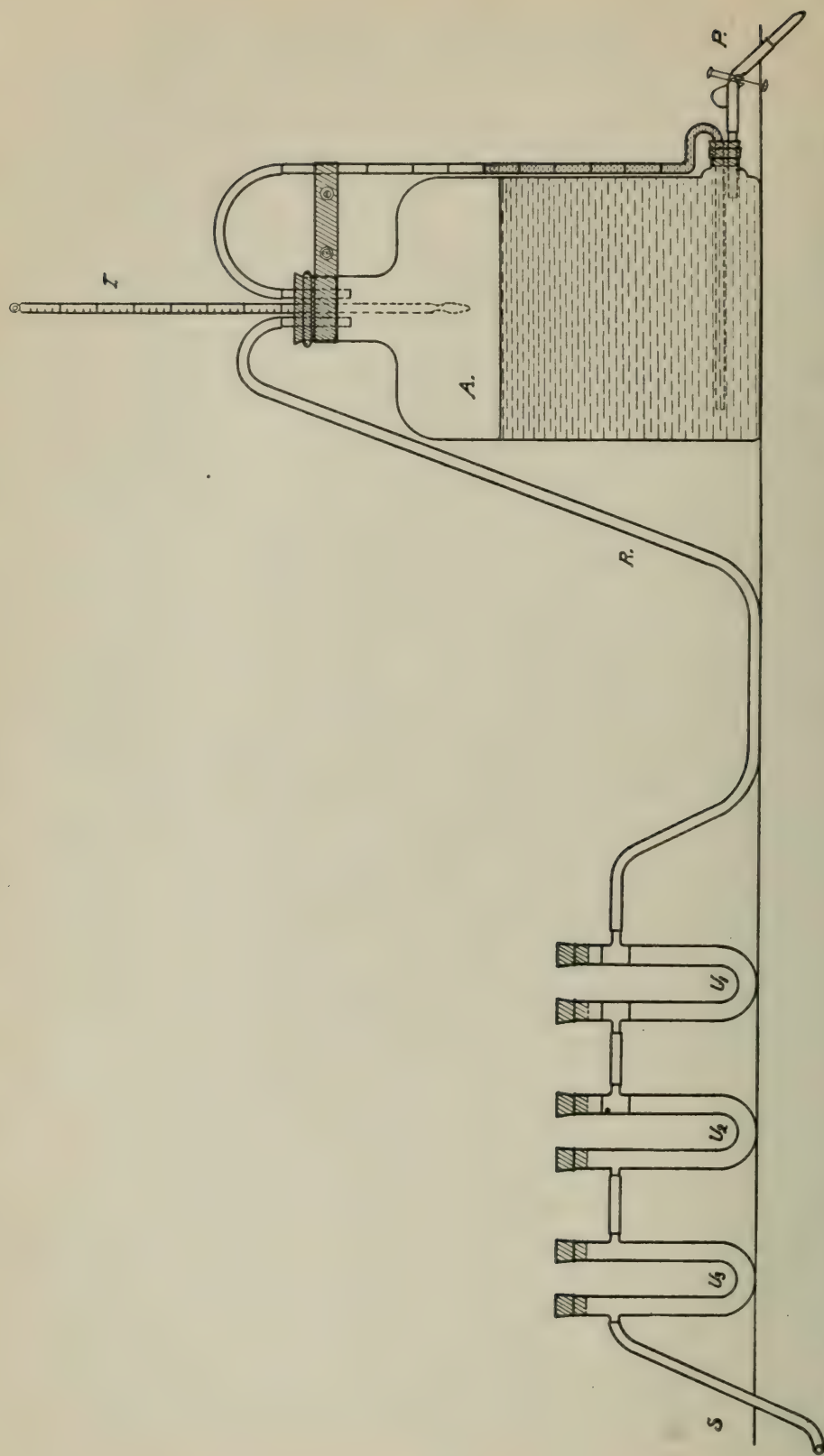


Fig. I. Apparatus used in determining the humidity of the air by the absolute method. U_1 contains fused calcium chloride; U_2 Anhydrous copper sulphate; U_3 concentrated sulphuric acid with pumice-stone. A , is a graduated water-bottle. R , a long pliable rubber tube. S , a short pliable rubber tube which may be inserted under hen or into incubator.

A is a large water-bottle, filled with water, and so graduated that a measured quantity may be drawn from it when the pinch-cock P is released. A thermometer T is inserted in the bottle. A rubber tube R joins A with a series of U tubes. U₁ contains calcium chloride freshly fused, so that all the water of crystallization is driven off; U₂ contains copper sulphate similarly treated; U₃ contains pumice stone and concentrated sulphuric acid. S is a short pliable rubber tube which may be inserted into an incubator or under a hen as desired. For convenience U₁, U₂ and U₃ are mounted on one small base so that they may be weighed. When a determination of the moisture in the air is desired, the U tubes are detached from the bottle, weighed, and then attached again. A measured quantity of water is let run from A, but as it does so the same volume of *air* must enter A, having first passed through U₃, U₂ and U₁ in succession. The U's are then detached and weighed again. The gain in weight gives the amount of water contained in the air drawn through. The weight of water in unit volume of air is sometimes called the "absolute humidity," and this method of determining the moisture content, an "absolute" method.

Investigations with apparatus such as illustrated in Fig. 1 soon showed a great variation in the moisture content of the air, even at a uniform temperature, also that for each temperature there was a limit—the air could contain a certain amount and no more. When it contained all it was capable of holding it was said to be "*saturated*," or to contain its "saturation amount" of moisture. It was also learned that the saturation amount varied with the temperature, the higher the temperature the greater the amount of moisture required to saturate the air. Saturation occurs during rain, mist, or fog; also near the ground when dew is falling. At 32° a room 10 feet long, 10 feet wide and 10 feet high is capable of holding in the air when saturated 5 ounces of water. At 70° it would hold 1 lb. 2 oz. when saturated, or nearly four times as much as at 32°. At 100° it would hold 2 lbs. 11 oz., which is more than twice as much as at 70°, and more than eight times as much as at 32°.

RELATIVE HUMIDITY, OR "HUMIDITY," AS IT IS USUALLY CALLED.

The air, however, is seldom saturated, only at times of rain, mist, fog, dew, snow, or some kindred phenomenon. At all other times it has less than its "saturation amount," and if we wish to convey an idea of the amount of moisture in the air at any time, we use the saturation amount as the standard of comparison, e.g., at 70° the saturation amount for a room 10 × 10 × 10 feet is 1 lb. 2 oz., or 18 oz., but if by use of the apparatus shown in Fig. 1 we were to find that the room at 70° contained only 9 oz., we would say that the air contained only *half* as much moisture as it was capable of holding, or that its *relative humidity* was 50 per cent. Thus at any particular time we may state the humidity of a room in two ways: (1) by giving the actual amount of moisture per unit volume, e.g.,

9 oz. per 1,000 cu. ft.—the “absolute humidity;” (2) by comparing the “absolute” with saturation, e.g., $\frac{9}{18}$ or 50 per cent.—the “relative humidity.” Of these the latter is the more useful. In the economy of nature evaporation plays a very important part. If evaporation from the ground is too rapid, the soil becomes parched and unfit for sustaining the plants growing upon it; if evaporation from the plants is too rapid, they wilt; if evaporation from our bodies is too rapid, we are conscious of feverish distress, while on the other hand if it is too slow, the air is oppressive and the perspiration, instead of evaporating, stands out in beads. These various phenomena are controlled by the *relative* humidity, not by the absolute. If the air has a low relative humidity the evaporation will be fast, but if a high relative humidity, it will be slow. Hence the “relative” humidity at any time furnishes us with much more valuable information than the “absolute.” In general practice the word “humidity” is used alone to stand for “relative humidity,” and will frequently be so used in the following pages.

THE WET- AND DRY-BULB THERMOMETERS.

But the absolute method of determining the relative humidity is very laborious and very exacting—one dare not even *breathe* on the U tubes, for the moisture that would condense on them from the breath would spoil the determination entirely in many cases (a fact which we learned by bitter experience), and it could only be employed where delicate balances were available; hence if humidity determinations were to have any extended application, some simpler method had to be evolved.

Now evaporation has a cooling effect, as any one may prove by the aid of two thermometers which read the same when dry. Wet the bulb of one with water as warm as the room and hold them side by side. In a very few moments the wet one will read several degrees lower than the dry one. This is explained by the fact that heat is used up in turning water into vapor, a familiar illustration of which is to be found in the kettle heating on the stove. The water becomes warmer and warmer until at last it begins to boil. Despite the fact that heat still passes into it the temperature remains at boiling point; the heat is absorbed in turning the water into vapor. The heat thus used is called *latent* heat, because it produces no change of temperature. It takes 5.38 times as much heat to vaporize the water as to heat it from freezing to boiling. Now whenever vaporization of water takes place this same latent heat is absorbed. If there is no fire to provide it then it must come from the evaporating water, the air, and surrounding objects. At first, the evaporating water on the wet thermometer draws most of its latent heat from the thermometer itself, hence the temperature is lowered. The faster the evaporation the greater amount of latent heat required in a given time, and hence the greater the reduction in temperature. But the rapidity of evaporation is controlled by the relative humidity of the air; the lower the humidity the

more rapid the evaporation, the higher the humidity the slower the evaporation. Hence the cooling produced on the wet thermometer is an inverse measure of the humidity.

As soon as these facts were correlated in this manner a secondary but simple method of determining humidity was at hand. A large number of determinations by some absolute method was made, and the results tabulated, and at the same time wet- and dry-bulb readings were taken and set down in the same tables opposite the corresponding humidities. When sufficient readings had been taken a law was established by which the humidities and wet- and dry-bulb readings for intermediate temperatures could be interpolated and the tables completed. When this had been done humidity determinations became easy: it was only necessary to take the wet- and dry-bulb readings and then refer to the tables for the humidity, which had previously been determined.

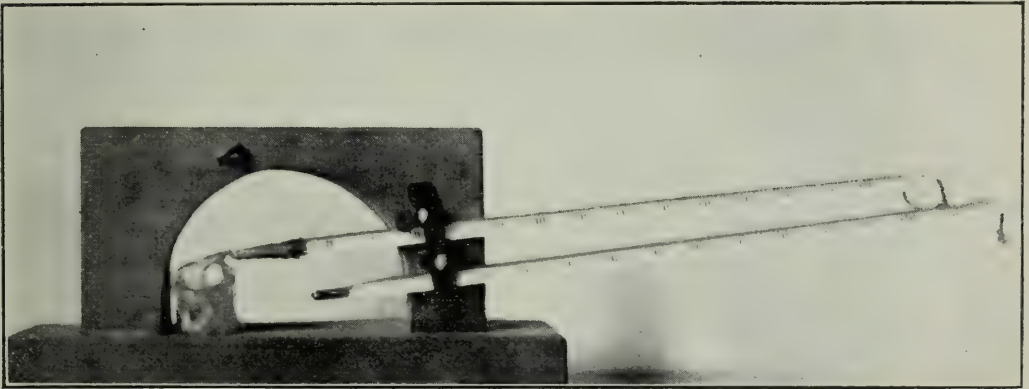


Fig. 2—Hygrometer used in incubators during 1906. In 1907 two holes were bored through the door frame of each incubator and long wet and dry bulbs inserted. This was found to be more satisfactory as it left the egg tray free, and the condition of the thermometer was always known, no trouble with filling the bottle and easier to read.

In order that the wet bulb may be continually kept moist, it is provided with a close-fitting linen sack to which is attached some candle-wick which dips into a small cup or bottle of water—the water travels up the wick to the sack as the oil ascends a lampwick.

Perhaps it should be mentioned that in making humidity tables as above described the wet bulb was gently fanned to dissipate the vapor being given off by it; for if this were not done, and the air were very stagnant, that lying close around the wet bulb would become highly vapor-charged, and the humidity determined would really be representative of only that small amount of highly charged air, not of the air generally.

HUMIDITY IN INCUBATORS.

When Mr. Graham invited us to assist in his investigations, the object was to study the humidity in incubators, for we did not then think of being able to determine the humidity in the hen's nest. The method we laid down for ourselves was: (1) To determine the humidity in incubators as ordinarily run; (2) to run incubators at various humidities, note the results, and thus determine whether humidity affects the hatch, and if so to learn the most desirable amount of moisture for the production of large hatches of strong chicks. For this work it was necessary to have a wet and dry bulb so mounted that they could be set in the incubators. Fig. 2 shows the form used.

At the outset it was thought wise also to rig up each incubator with a small motor fan which could be run to fan the wet bulb in order to arrive at the proper humidity in case the incubator air should be so stagnant as to give a false reading without fanning. Fig. 3 shows the hygrometer (wet and dry bulb) together with fan and battery to run it.



Fig. 3—Small motor fan which was set inside the incubator to fan the wet- and dry-bulb hygrometer.

Testing this apparatus in the room, we learned that at middle humidities fanning makes practically no difference in the readings, but at high or low humidities it makes a great deal. In the incubators fanning always made a great difference, giving much lower readings than without fanning, showing incidentally that the circulation of the incubators is not equal in effect to free diffusion in the room. The use of the fan in the incubator had one defect, however: it disturbed the normal conditions whenever a reading was taken, stirring up the warm and cold layers and almost invariably raising the temperature near the eggs for the moment and thus giving a humidity somewhat too low. Table No. IX. contains a record of the hatches run during the season of 1906.

TABLE IX.—HUMIDITY, EVAPORATION, CO₂, AND HATCH OF INCUBATORS.

Incubator.	When set.	How Run.	Humidity of Room.	Humidity of Incubator.		Per Cent. Evaporation from Eggs.	CO ₂ in 10,000 Parts.	Per Cent. Hatched.	
				With Fanning.	Without Fanning.			Of Fertile Eggs.	Of Total Set.
Chatham 5	June 25...	Dry fanned, day...	62.9	40.5	.....	11.0	.....	.....	.....
	July 20...	"	66.2	38.5	.....	12.5	8.9(3)	* 61.5	*53.3
	Aug. 20...	Moisture in bottom.	51.8	62.4	76.1	11.1	.....	{ * 85.7	*80.0
Chatham 6	June 25...	Dry	62.9	37.4	.....	9.1	.....	{ + 76.3	+61.0
	July 18...	"	62.3	41.0	47.2(7)	14.6	8.1(2)	.....	.....
	Aug. 12...	"	68.1	40.7	51.2(8)	14.8	6.5(3)	{ * 78.6	*73.0
—Chatham	July 20...	Dry	66.2	34.6	.....	15.8	9.3(3)	{ + 65.0	+47.0
	July 20...	"	66.2	37.3	51.0	14.6	7.8(2)	.....	.....
	Aug. 20...	Moisture on top...	51.8	60.3	71.7	14.0	.....	{ * 71.4	*66.7
New Prairie State	Aug. 7...	Moisture in bottom.	69.3	58.9 (3)	76.6	9.2	{ 3.3(no eggs)	{ + 71.0	+57.0
	"	"	.....	.....	.....	9.1	{ 7.3(10)	{ * 72.0	*53.0
	Sept.....	"	.....	.....	.....	.....	7.3(9)	{ + 68.0	+50.0
Old Prairie State	July 17...	Dry	62.3	33.9	.....	15.8	6.7(2)	{ * 65.4	*56.6
	Aug. 12...	"	68.1	33.0	42.3(12)	15.3	5.6(3)	{ + 70.0	+61.0
	.....	.....	.....	.....	.....	.....	.....	{ * 69.0	*60.0
Cyphers, Chas. A	July 17...	Dry	62.3	35.9	44.8(6)	16.6	.....	{ + 65.0	+45.7
	Aug. 12...	"	68.1	37.4	50.4(12)	16.7	5.4(4)	.....	.....
	.....	.....	.....	.....	.....	.....	.....	{ * 78.0	*68.0
Dry Machines	Averages...	.....	65.1	39.0	47.6	14.6	.....	{ + 70.0	+48.0
	.....	.....	.....	.....	.....	.....	.....	{ * 71.8	*63.6
	.....	.....	.....	.....	.....	.....	7.3	{ + 66.7	+46.9
Wet Machines.	Averages...	.....	57.6	60.5	74.8	11.4	{ 3.2(no eggs)	{ * 73.6	*64.1
	Chatham 2	.....	.....	.....	.....	.....	3.3	{ + 71.3	+57.3
	Front Room	.....	.....	.....	.....	.....	.....	.....	.....
Incubator Room	.....	.....	.....	.....	.....	.....	4.6, hens's level	.....	.....
	.....	.....	.....	.....	.....	.....	2.8, machine	.....	.....
	.....	.....	.....	.....	.....	.....	level	.....	.....

* Selected

Shuffled.

It will be observed that the humidity of the dry machines varies within narrow limits, likewise that of the wet machines, but there is a great difference between the former as a class and the latter, the relative humidity of the latter being about one-half higher than that of the former.

RELATIVE HUMIDITY UNDER HENS.

We had not proceeded very far, however, when we became convinced that if our work was to have its greatest value, we must learn the conditions existing in the hen's nest. To determine the humidity in the nest, we devised the hygrometer shown in Fig. 4 (see page 39). It consists of an egg of brass strainer gauze held in shape by two perforated discs, and fitted with two tin tubes through which the wet- and dry-bulb thermometers could be inserted. To determine the humidity in the nest the "egg" was to be inserted beneath the hen, the thermometers projecting so that the readings could be taken. But I feared the vapor from the wet bulb would saturate the air under the hen. To learn if this were possible it was necessary to know the volume of air among the eggs in the nest, the amount of vapor that air was capable of holding at 100° (the temperature of the nest) and the amount of water on the sack of the wet bulb. If the latter amount was equal to or greater than the former then it would be *possible*, other conditions favoring, for the egg hygrometer to saturate the air in the nest. To gain some idea of the quantity of air in the nest a circular, flat-bottomed dish, with upright sides, was procured which just held 13 eggs in one layer. Water was poured in till the eggs were *just* covered. It took 42.5 cubic inches. This represents the air space between the eggs. Then of course something had to be allowed for the extra air space caused by the presence of the hen's legs and breast between the eggs. We thought that 17.5 cubic inches would be sufficient, making a total of 42.5 plus 17.5, or 60 cubic inches. Turning up our humidity tables we found that 1 cubic foot of air at 100° was capable of holding 19.8 grains, whence by calculation 60 cubic inches would hold .68 grains, or almost exactly two-thirds of a grain. Then weighing the thermometer before and after wetting, we found that the sack absorbed 1.27 grains, or nearly twice the saturation amount for the air in the nest. Hence if the vapor from the wet bulb were not dissipated too rapidly it should saturate the nest air. In proof of this argument the hygrometer was placed in a rubber-stoppered bottle containing incidentally just half as much air as the nest, the thermometers projecting through holes in the stopper. In three hours' time the humidity had risen from 62.9 to 95.2 per cent., pretty close to saturation, and *the sack was still thoroughly wet*.

Knowing thus the behavior of the hygrometer in a closed-up stagnant air, we next placed it under a hen. Would it saturate the air there? Here are the readings and remarks:

TABLE X. EGG HYGROMETER IN BOTTLE CONTAINING AIR.

Time in bottle.	Humidity in Bottle.	Humidity of Room.
0 minutes	62.9	62.9
5 "	85.6	
10 "	87.9	
20 "	90.2	
40 "	92.7	
3 hours	95.2	

TABLE XI. EGG HYGROMETER UNDER BUFF ORPINGTON ON STRAW NEST.

Time.	Nest Temperature.	Humidity in nest.	Humidity of Room.
0 minutes			46.0
5 "	98.75	70.6	
10 "	101.25	69.7	
15 "	101.75	69.8	
20 "	102.0	69.9	
30 "	102.0	71.5 (?)	
Gauze becoming dry. Gauze wetted afresh.			
40 "	102.25	70.0	
50 "	102.0	71.0	
60 "	100.5	69.6	
70 "	100.5	68.1	
80 "	100.0	64.4 (?)	
Gauze wetted afresh.			
90 "	99.5	69.3	
100 "	100.5	74.7	
110 "	100.5	72.6	
		Average 70.1	

During two hours the sack became dry twice and almost dry again, enough water having thus evaporated to saturate the nest air six times over. Yet the humidity was practically constant from the very first reading! Very different from the behavior in the bottle. Hence we concluded it was impossible for the hygrometer to saturate the nest air. The vapor must be passing from the nest quite rapidly.

But the clearing away of one objection raised another: since so much vapor is being dissipated, it is possible the close-meshed wire gauze is hindering free diffusion, thus to a certain extent bottling up the vapor around the thermometer. If so the humidity in the "egg" does not represent that in the nest generally. Before this objection could be satisfactorily answered it was necessary to begin the humidity determinations under the hens already set. The results are shown in the following table:

TABLE XII.—HUMIDITY, EVAPORATION, CO₂, AND HATCH OF HENS.

Hens.	When Set.	Nest.	Humidity of air near hens.	Humidity in Nest.		Per cent. evaporation from eggs.	CO ₂ in 10,000 parts.	Per cent. Hatched.	
				Egg Hygrometer.	Frame Hygrometer.			Of Fertile Eggs.	Of Total Set.
Buff O...	July 17...	Under brooder.....	62.3	75.7	60.0	10.7	39.3 (3)	.....	.....
Buff O...	July 17...	Damp earth in room.	62.3	73.4	57.7	11.1	27.4 (3)	.....	.....
Buff O...	July 20...	" " "	66.2	76.0	60.3	11.4	24.5 (1)	91.7	73.3
S. J. W.	July 28...	Ground, open air.....	.....	76.9	61.2	11.8	20.0 (8)	84.6	73.3
W. R....	August 7...	In artichokes.....	77.7	80.0	64.3	9.8	28.5 (10)	85.7	80.0
Buff O...	August 17.	Earth, room.....	73.4	75.4	59.7	11.5	26.0 (3)	92.3	80.0
B. R....	August 22.	In evergreens.....	67.0	76.2	60.5	11.5	23.4 (2)	75.0	60.0 (2 broken)
.....	.....	Ground beneath box.	.....	.....	.....	10.2	.....	100	73.0
Averages	.....	.....	68.1	76.2	60.5	11.0	27.0	88.2	73.3
S. L. W.	July 17...	Chaff.....	62.3	73.9	58.2	11.4	22.2	.....	.....
Buff O...	August 17.	In colony house.....	67.1	75.9	60.2	12.1	.....	85.7	80.0
Averages	.....	.....	64.7	74.9	59.2	11.7	.....	.....	.....
Buff O...	July 20...	Board.....	66.2	76.9	61.2	13.3	18.9 (2)	78.6	68.8
Buff O...	August 17.	Board.....	73.3	75.9	60.2	12.8	26.0 (3)	80.0	53 (5 broken)
Averages	.....	.....	69.7	76.4	60.2	13.0	22.4	79.3	60.9
L. B. 2..	July 4....	Ventilated.....	61.1	64.4	48.4	14.7	.....	.....	.....
Buff O...	July 17...	" " "	62.3	73.3	57.6	13.1	26.6 (3)	.....	.....
Buff O...	July 20...	" " "	66.2	70.4	54.7	14.7	13.3 (1) (?)	77.0	66.7
Averages	.....	.....	63.2	69.4	53.6	14.2	19.9	.....	.....
B. R. 3866	August 7..	Rubber.....	69.3	77.1	61.4	10.8	21.4 (10)	100.0	80.0
B. R. 7100	.....	Rubber, no eggs.....	.....	.....	.....	.....	10.4 (10)	.....	.....
Averages of all hens	on eggs.....	.....	67.4	70.1	59.2	12.0	24.4	86.0	71.5

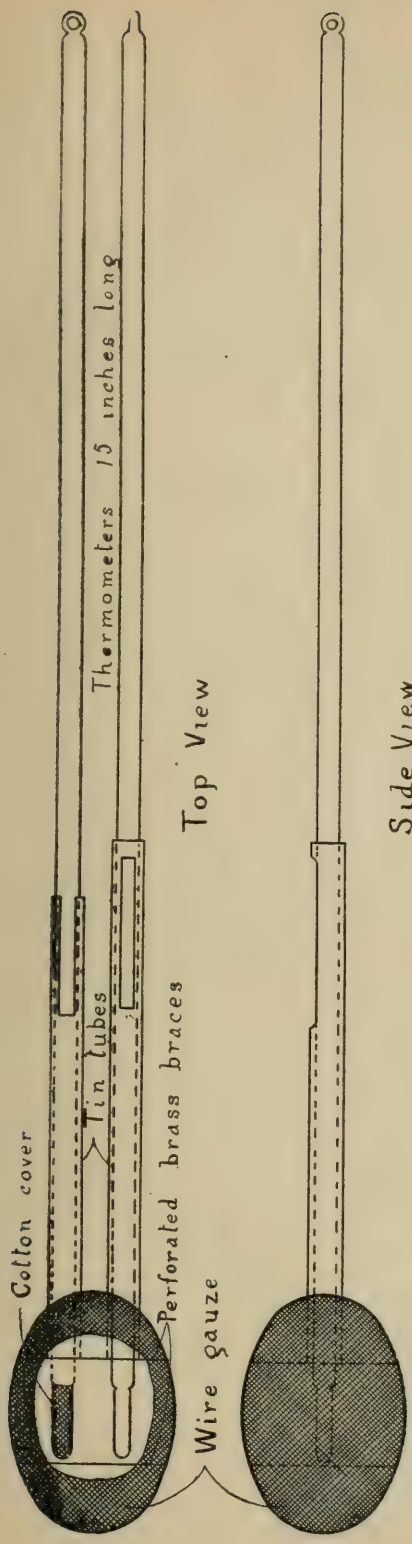


Fig. 4—Nest Hygrometer ("Egg Hygrometer").
Wet- and Dry-bulb Thermometers in Egg of Wire Gauze.

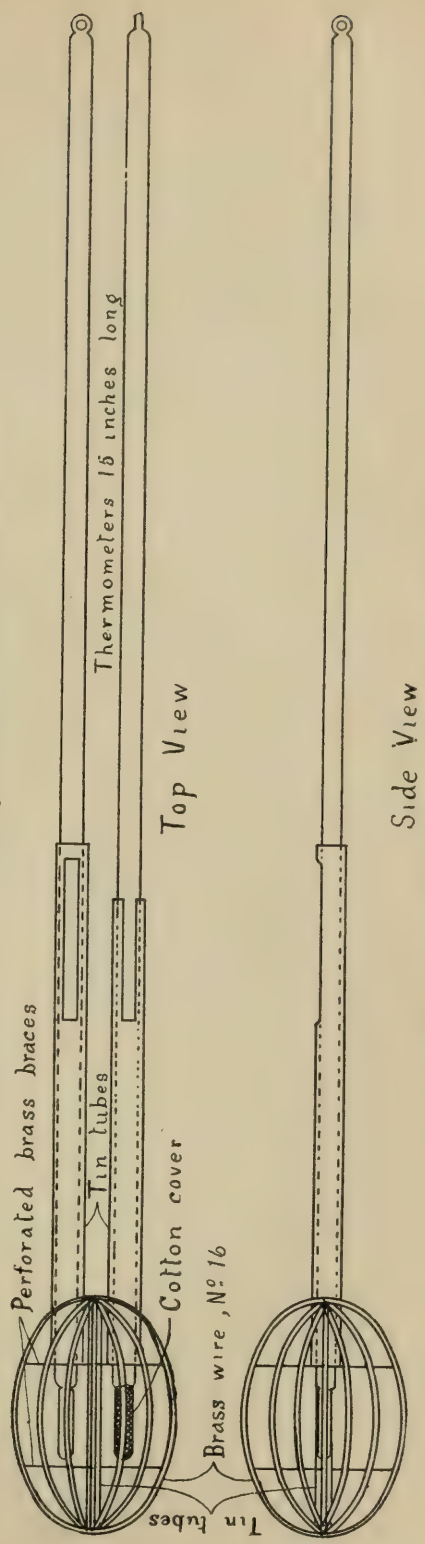


Fig. 5.—Nest Hygrometer ("Frame Hygrometer")
Wet- and Dry-bulb Thermometers in a Wire Frame Egg.

Comparing this table with No. IX., it will be observed that the humidity in the nests appeared even higher than in the wet incubators without fanning. This seemed incredible, and thus the objection previously mentioned seemed emphasized. To examine its validity a new hygrometer was devised, of which Fig. 5 is an illustration. In general design it is the same as the former, but the wire gauze is supplanted by a framework of wires converging from the centre on the ends of the egg, and being about one-half an inch apart at the widest point. This instrument we called the "frame hygrometer." The wires, we thought, could not have much effect in checking diffusion. To establish this point it was tested against an ordinary wet and dry bulb, unsheltered, and subject to free diffusion in the room. The results are given below :

TABLE XIII. COMPARISON OF FRAME HYGROMETER WITH ORDINARY HYGROMETER IN ROOM.

Temperature.	Ordinary Hygrometer.	Frame Hygrometer.	Difference.
75.5	38.9	42.2	3.3
75.5	40.7	42.6	1.9
75.5	40.7	43.0	2.3
75.5	38.9	41.2	2.3
75.5	38.9	42.6	3.7
76.0	41.2	44.8	3.6
76.0	38.9	42.6	3.7
67.0	64.2	66.6	2.4
95.0	74.6	74.6	0.0
76.0	34.0	34.0	0.0
	(fanned)	(fanned)	

The greatest difference is not large and with high humidity, or when fanned, the difference was nil. Having thus established that the "frame hygrometer" is at worst very nearly correct in the room, we proceeded to test the "egg hygrometer" by it. Selecting a hen in whose nest the "egg" had previously given a humidity of 74.3 (the average of ten readings) we put in the "frame." It gave a humidity of only 60.1 per cent., 14.1 per cent. lower than that given by the "egg." It seemed incredible that the difference could be so large, but repeated tests gave the same result. Then both were put under her at the same time, the "egg" on the left, the "frame" on the right, giving 65.8 and 50.6 respectively, a difference of 15.2. Another hen was selected, a White Wyandotte, under evergreens. Result: egg gave humidity of 73.9, frame 59.8, difference 14.1. Later in the day Mr. McKenney tested the same hen with the following result: egg 74.2, frame 56.7, difference 17.5. These facts are tabulated as follows :

TABLE XIV. FIRST COMPARISON OF EGG AND FRAME HYGROMETERS UNDER HENS.

Hen.	Nest.	Egg hygrometer.		Frame hygrometer.		Difference.
		Remarks.	Humidity.	Remarks.	Humidity.	
Bu. O.	Damp earth.....	Average of 10 readings.....	74.3			
"	"	.....		One reading.....	60.1	14.2
"	"	Egg on right.....	65.8	Frame on left.....	50.6	15.2
W. W.	Under evergreens.	Egg on left.....	73.9	" " right....	59.8	14.1
"	"	Reading by A. M. later in day....	74.2	Reading by A. M. later in day...	56.7	17.5

Not yet reconciled to such a great difference, we selected another hen for a more extended and exhaustive test. To begin with, the dry thermometers were placed toward the body. The wet ones outward from it. They were later interchanged, and lastly the "egg," which had been on the left side, was changed to the right, and the "frame" vice versa.

The difference ranged from 14.6 to 17.9, and averaged 15.9. The readings complete are given in Table No. XV.:

TABLE XV. SECOND COMPARISON OF EGG AND FRAME HYGROMETERS UNDER BUFF ORPINGTON HEN ON DAMP EARTH NEST.

Time.	Egg Hygrometer.			Frame Hygrometer.			Difference.
	Remarks.	Temperature.	Humidity.	Remarks.	Temperature.	Humidity.	
10.25	Left, wet outward.....	100.0	69.4	.....	.....	.....	.....
10.50	" ".....	99.0	67.6	Right, wet outward.	99.0	53.0	14.6
11.00	Gauze dry, wetted.....	.....	.....	Gauze wetted.....	.....	.....	.....
11.10	Left, wet outward.....	99.5	70.8	Right, wet outward.	99.0	55.8	15.0
11.12	Positions interchanged.	.....	.....	.....	.....	.....	.....
11.30	Right, wet inward.....	98.0	70.2	Left, wet inward...	100.0	53.4	16.8
11.40	" ".....	99.5	70.8	" ".....	99.5	54.6	16.2
	Gauze wetted. ....	.....	.....	Gauze wetted.....	.....	.....	.....
11.50	Right, wet inward	100.0	74.1	Left, wet inward...	100.00	56.2	17.9
11.55	" ".....	99.0	72.3	" ".....	98.5	55.6	16.7
12.00	" ".....	99.5	70.8	" ".....	99.0	55.8	15.0
				Average.....			15.9

These tests established beyond doubt that our second objection was well founded, that the "egg" did bottle up the moisture and thus give readings far too high. If all the differences of both tests are averaged we find the egg readings too great by 15.7. Referring to Table XII., and subtracting 15.7 from the "egg" humidities, we obtain the next column, the humidities by the "frame."

But doubtless in the minds of some there is an objection to even the "frame" hygrometer: The wet bulb is giving vapor to the air in the nest, and although it *cannot* give enough to *saturate* the air, still it may be giving sufficient to raise the humidity considerably above what it would be if the wet bulb were not there. This objection seems plausible, but it may be stated here that during the present season (1907) the "frame" hygrometer in the nest was subjected to a rigorous test by the absolute method and it was established that the hygrometer readings are not in error to any appreciable extent. Details of this test will be given later in another connection. Then taking as correct the humidity of the nests as given by the frame hygrometer, we observe that it is very much higher than the fanned reading in the dry machines, as 59 is to 39. (See Tables IX. and XII.) Hence if we are to take the hen as our guide we must infer that dry incubators have not sufficient moisture, and that incubators cannot be expected to give best results unless they are made as moist as the hen's nest.

Now referring to Table XII., and comparing the various kinds of nests, we observe that the rubber and the earth nests had highest humidity, and that *they also hatched best*. Barring the board nests, where 5 eggs were broken, the hatch increased or decreased as the humidity did. Referring to Table No. IX., it will be seen also that on the average the "wet" machines, or machines into which moisture was introduced, gave *a considerably greater hatch than did the dry ones*, in the case of both the selected and the shuffled eggs, though the difference was the more marked on the latter. Hence from the *practical* side also for both the hens and the incubators we thought it a fair conclusion from the work of 1906 that high humidity must be productive of larger hatches. This conclusion has been thoroughly confirmed by the extended tests of 1907. Consulting Table No. VII., the reader will observe that 1,221 eggs were set in machines where moisture was introduced by use of water only, and 1,406 in dry machines. In the "wet" machines the hatch was 51.9 per cent. of the total eggs set; in the "dry" machines it was only 40.7 per cent. Then besides, more chicks hatched in "wet" machines lived than those hatched in dry ones, 63 per cent. of the former living to the age of four weeks as against 39.5 per cent. of the latter, or, counting the chicks alive at the end of four weeks in terms of total eggs set, the "wet" machines produced 32.7 per cent. as many chicks as eggs set and the dry machines 16.1 per cent., or less than half as many as the wet. Or stating it otherwise, 3 eggs in a wet machine produce 1 chick four weeks of age, while it takes 6 eggs in a dry machine to produce 1 chick

the same age. This is a very remarkable substantiation in a practical way of our conclusion that since the air in the nest is very moist that in an incubator must also be very moist for best results.

But a comparison between Tables IX. and XII. will show that although the humidity of the "wet" incubators with fanning (which approximates to the correct humidity, the unfanned being too high), is slightly higher than that of the hens by the frame hygrometer (which also approximates to the correct reading) still the selected eggs in the incubators did not hatch nearly so well as those under the hens (all eggs set under hens were selected). This being the case, we must conclude that some vitalizing power (or powers) present with the hens was absent from the incubators.

CIRCULATION IN NEST.

In the work on humidity thus far reported there lies almost hidden a suggestion of a condition in a hen's nest not generally suspected, certainly not formerly suspected by us, which may ultimately be shown to be that vitalizing influence, or at least one such. The reader will recall that when the "egg" hygrometer was placed in the stoppered bottle, the sack did not become dry even in three hours' time, and the humidity rose almost to saturation. He will also recall, or by referring to Table No. XI., he may again observe, that when the same hygrometer was placed in a hen's nest it became dry in less than 40 minutes, and dry again in about 45 minutes more, and partly dry a third time in 30 minutes, enough water having thus evaporated to saturate the air at least four or five times over, notwithstanding which the humidity in the nest remained constant at only 70 per cent. These facts surprised me greatly at first, and they suggested to my mind the idea of a *fairly rapid change of air in the hen's nest*. To gain further light upon this point, the "egg" and "frame" were tested against each other in the room subject to free diffusion. The results are given in Table No. XVI. :

TABLE XVI. COMPARISON OF EGG AND FRAME HYGROMETER IN ROOM.

Room Temperature.	Humidity of Room by Ordinary Hygrometer.	Difference between Humidities given by Egg and Frame Hygrometers.
		Per cent.
76	40.7	23.3—diffusion
68	66.3	12.7 (2)—diffusion
96	48.9	9.0—diffusion
	48.9	11.6—fanned
	48.9	11.1—fanned 10" away
	49.2	3.7—fanned 1" away
	52.4	7.0—fanned 18" away
	43.7	10.7—fanned 10" away
	48.9	12.8—fanned 6" away

FLOOR WATERED.

Room Temperature.	Humidity of Room by Ordinary Hygrometer.	Difference between Humidities given by Egg and Frame Hygrometers.
95.5	74.6	Per cent. 3.5—diffusion .3—fanned 6" away 5.2—fanned 10" away 3.1—fanned 18" away

The first reading shows that when the humidity was low the difference was high, 23.3 as compared with 15.7 in the hens' nests. The second reading shows that with higher humidity the difference was less, being only 12.7. Many readings not recorded here were taken from time to time at average humidities of from 50 to 65, and the difference was always in the neighborhood of 15 per cent., very close to the difference in the nest. Was it possible that the air-movement in the hen's nest was equivalent to free diffusion in the room? It did not seem credible. The temperatures of course are not the same in the two cases, so that the tests are not exactly parallel, still the existence of the same difference between the hygrometers in the nest, as in the room, pointed strongly to the suspicion that the nest was subject to air movement equal in effect to the free diffusion of the room. If so, then the reading of the "frame" hygrometer was really a fanned reading, and, therefore, strictly accurate; of which more later.

But how can we reconcile the ideas of rapid air movement and high nest humidity? Surely there is not enough evaporation from the eggs to maintain such high humidity in the face of such rapid circulation. Let us examine. Referring to Table XII., under "evaporation" we learn that the average loss from all eggs under hens in 1906 was 12 per cent. of their original weight. The ventilated and board nests, however, are unnatural conditions, and the evaporation is high, hence in any argument based on evaporation these nests should be omitted. The average evaporation in the remaining kinds of nests is 11 per cent. The weight of a setting of eggs is about 26 ounces, and the evaporation would thus be 2.86 ounces. And this divided up equally amongst the first 19 days is sufficient to saturate the air under the hen at least *four* times an hour for the whole period. This known, it is not so difficult to conceive of high humidity in the face of rapid air movement. Moreover, it is possible that some moisture comes from the hen's body, aiding in the maintenance of the high humidity.

CIRCULATION IN INCUBATORS.

The idea of circulation in the nests led us to the consideration of circulation in incubators, but owing to the incompleteness of the work on the former the latter has been held in abeyance. It may be stated, however, that the differential reading between the "egg" and the "frame"

hygrometers when placed in wet incubators was much less than when under the hens and quite variable in any individual incubator. In the very driest of the dry the difference was almost the same as under the hens. That variation in circulation affects the differential reading may be seen from Table XVI. When testing the "egg" against the "frame" in the room a little Ajax motor-fan was used to produce movement of air past them. The distance of the fan from the hygrometers was varied, hence the rate of circulation was likewise varied. It will be seen that for both low and high humidities (temperature 96 in both cases) there is a rate of circulation which gives a maximum differential reading, and also that either faster or slower circulation will reduce the difference. Therefore since the differential was lower in the wet incubators than under the hens the circulation was different, either faster or slower. Likewise since the differential in the dry machines was equal to that under the hens, the circulation must have been different, for the same amount of circulation produces a much greater differential in a dry than in a moist atmosphere. Whether the circulation in the incubators is greater or less than that under hens we are not able to say from *direct measurement*, but we have, however, indirect proof that seems to indicate unmistakably that the incubator circulation is considerably the slower, proof that came to us during our study of nest humidity by the absolute method.

HUMIDITY BY THE ABSOLUTE METHOD.

To determine humidity absolutely has given us more trouble than any other part of the work. In 1906, being busy with other problems, and having only a short time to devote to it, it baffled us entirely. Although it looks easy in description, as given on pages 29 to 32, it is difficult in application. When beginning to use it last year we made a number of determinations of the room humidity by it one after another, to test the method. The variations were so great that it was evident that something was wrong in the manipulation. The drying tubes were weighed, 500 cc. of air drawn through them, and then re-weighed. The operation was repeated over and over several times in succession, but often the tubes would gain two or three times as much in weight as the time before, while the wet- and dry-bulb readings would show constant humidity. In the spring of 1907, with more time at our disposal, it was discovered that the variations were largely due to condensation on the tubes of moisture from the breath when it happened to be directed against the cold glass. From that time on a mask was worn by the operator so that the breath could not possibly strike the tubes. As a further precaution rubber gloves were worn, so that no perspiration from the hands could condense on the tube. With these precautions we were able to determine the humidity of the room correctly by this method. Seventeen comparisons extending from May to August gave the following results:

Wet and dry bulb, average relative humidity, 49.5 per cent.

Absolute method, average relative humidity, 49.3 per cent.

ACTUAL HUMIDITY IN INCUBATORS.

Having thus established our manipulation of the absolute method, we could with confidence use it in determining the relative humidity in incubators and in nests. A series of machines and several hens were set in August for this special study. For the machines three facts were recorded at each determination: (1) the humidity of the room and the corresponding vapor pressure; (2) the *apparent* humidity in the incubator by the wet and dry bulb without fanning and the corresponding vapor pressure, two or three readings for one determination; (3) the *actual* humidity in the incubator by the *absolute* method and the corresponding vapor pressure, two or three readings for one determination.

Perhaps some explanation should be made of the term "vapor pressure." Every gas or vapor has an expansive power, a fact which may be shown as follows: Tie tightly a thin rubber over the mouth of a glass beaker, place it in the receiver of an air-pump, and exhaust the air from the receiver. The rubber will be seen to bulge outward as the air from around it is pumped away. Hence the air within the beaker has an expansive power. This causes it to exert a *pressure* outward on the rubber. The outside air had the same power in equal measure and as long as it was present to exert its pressure on the top, the rubber being equally pressed in both directions, was neither bulged outward nor depressed inward. But as soon as the outside air was partly removed and its pressure reduced, the expansive power of the air within manifested itself. Now, air possesses this property when not confined in a vessel, but expansion is prevented by the weight of the air above. That water vapor has an expansive power and exerts a pressure may be shown in a similar way. The more vapor in the air at any given temperature the greater the pressure it (the vapor) exerts. When vapor issues from the tea-kettle its pressure is higher than that in the air around and hence that vapor expands and keeps on expanding till the vapor pressure throughout the room is uniform. This equalization would occur even if the *air* were perfectly motionless. It is much hastened by air currents. There are various ways of determining the pressure of the vapor in the air at any time, but they are all too involved to be given here. Suffice it to say that when the temperature of the air and the weight of vapor in a cubic foot are known, then by applying certain physical laws, and performing a long mathematical calculation, we are able to determine the corresponding vapor pressure. In this calculation correction is made for the contraction of the air when entering the cold bottle A (Fig. 1). When this vapor pressure is known we are able to state the natural tendency of the moisture. If the vapor pressure outside the machine is greater than inside, then the room moisture would by its greater pressure pass through the cracks into the incubator. If on the other hand the pressure within is greater, then the moisture within will pass outward.

Five machines were examined in this test. The result is given in Table No. XVII.:

TABLE XVII: ACTUAL *vs.* APPARENT HUMIDITY IN INCUBATORS.

Incubators.	How run.	Humidity of room by wet- and dry-bulb method.	Vapour pressure in room deduced from wet- and dry-bulb readings.	Apparent humidity of incubator by wet- and dry-bulb method.	Apparent vapour pressure in incubator deduced from wet- and dry-bulb readings.	Actual humidity of incubator by absolute method.	Actual vapour pressure in incubator deduced from absolute readings.
		%	Inches.	%	Inches of mercury.	%	Inches of mercury.
No. I. Prairie State	{ Fumes. Moisture by water in sand tray. }	60.6	.458	55.4	1.116	46.6	.953
No. II. Prairie State	Dry.	61.3	.444	34.4	.689	21.3	.433
No. III. Prairie State	{ CO ₂ and moisture by water in sand tray. }	59.7	.423	47.8	.967	45.8	.928
No. IV. Prairie State	{ Zenoleum and moisture by water in sand tray. }	59.7	.414	53.0	1.091	46.1	.936
No. VII. Model	{ Buttermilk. Tray nearly full size of machine bottom. }	61.0	.412	61.5	1.276	54.4	1.135

In this table the wet- and dry-bulb results are the averages of from three to five readings, the "absolute" results of from seven to ten readings. Perhaps the dry machine should be noticed first. The actual humidity was only 21.3 per cent., an average of ten readings taken on five different days. Of these ten only one was greater than 22 per cent., and only two less than 19 per cent. In fact one of the outstanding features of this test was the uniform humidity of this dry machine; come back to it when I would, its humidity was always the same within very narrow limits of variability. Another noteworthy fact with regard to this machine is that the vapor pressure in it was practically the same as in the room, .433 inches for the former and .444 inches for the latter. The room pressure was the average of five readings taken on the same five days as the incubator readings. Since these pressures were nearly equal, there would be little transference of vapor either way. But all determinations were made during the day. At night with a drop in temperature the room vapor pressure would fall, under which conditions vapor would pass from the incubator to the room. The apparent humidity by the wet and dry bulb method was much higher than the actual as 34.4 to 21.3, *i.e.*, the apparent is astray 13.1 on 21.3, an error of 61.5 per cent. This great discrep-

ancy is due to the lack of circulation, the moisture given off by the wet-bulb not being dissipated fast enough to indicate the true humidity. This result proves absolutely the 1906 conclusion from theoretic considerations that the real humidity of an incubator is not learned by the use of the wet- and dry-bulb hygrometer without fanning. Again, as fanning disturbs the normal conditions within the machine, the fanned reading, while correct for the artificial conditions, does not represent the exact humidity under normal conditions. Hence the only way to gain reliable information as to the actual humidity in an incubator is by this or some other "absolute" method.

Machines I., III., and IV., being all of the same make, with the moisture provided in the same way, would be expected to have approximately the same humidity. From the column "actual humidity" this would appear to be the case, while from "apparent humidity" I. and IV. are nearly alike, but III. considerably lower. The explanation of this apparent discrepancy is found in the individual readings of which 47.8 and 45.8 are the averages. During the first ten days of incubation the humidity in III. was low, apparent 43.4, real 35.5; difference 7.9. During the remainder of the hatch it was high, apparent 56.6, real 50.8; difference 5.8. It so happened that for this machine two-thirds of the readings for the "apparent" were taken while the humidity was low, but that three-fourths of those for the "real" were taken while the humidity was high. Hence the average of the "apparent humidities" is too low and of the "real humidities" too high to represent the true averages for the whole hatching period. The cause of the low humidity in this apparently moist machine during the first ten days was not discovered. The difference between the apparent and true humidities was 7.9 during the dry period and 5.8 during the moist period. In I. it was 8.8; in IV., 6.9; in VII., where the moisture was provided in the form of buttermilk, the difference was 7.5. Thus in the moist machines, too, we see that the humidity as given by the wet- and dry-bulb hygrometer is astray, an error of 7.5 (average difference) on 47.5 (average real humidity) or 15.8 per cent., and we again remark that for reliable information on the humidity in incubators an absolute method is essential.

The actual vapor pressure in these "moist" machines was in all cases more than double that in the room at the same time, and in No. VII. it was nearly three times that in the room. Hence in all these cases there would be a strong tendency for the vapor to pass outwards through the cracks.

ACTUAL HUMIDITY IN NESTS.

The same methods were applied to determining the actual humidity in hens' nests. The results are given in Table No. XVIII. :

TABLE XVIII: ACTUAL vs. APPARENT HUMIDITY IN NESTS.

Hen.	Kind of nest.	Humidity of room by wet and dry-bulb method.	Vapour pressure in room deduced from wet and dry-bulb readings.	Apparent humidity in nest by the frame hygrometer.	Apparent vapour pressure in nests deduced from hygrometer readings.	Actual humidity in nest by absolute method.	Actual vapour pressure deduced from the absolute readings.
I. Silver Laced Wyandotte.....	Earth	62.9	.427	75.2	1.314	82.1	1.659
II. Silver Pencilled Wyandotte	Earth	62.7	.431	68.4	1.252	59.4	1.203
	Averages for earth nests..			71.8	1.283	70.8	1.431
III. Barred Rock	Straw	65.0	.437	.....	.....	52.8	1.074

It was found that several samples could not be taken in succession, for the second and third were invariably lower than the first. Great variations in humidity were found in all nests. For hen No. I. the range was 70.6 per cent. to 99.3 per cent.; for No. II., 48 to 83; for No. III., 40.5 to 60.4. Readings were taken in the top of the nest, the bottom, and between the leg and breast, but no uniformity was reached. Of seven readings for hen No. I. the highest was obtained at the bottom, the next three in order were top readings, the remaining three, bottom readings. For hen No. II. the highest was a top reading, the next three were bottom readings, and the remaining one a top reading. For No. III. the highest was between the leg and breast, the second and third bottom readings, the fourth a top reading; the fifth between the leg and breast, and last a bottom reading. Probably much of the variation with these hens might be accounted for if we knew how closely or remotely the reading followed some shifting of the hens. The humidity in nests I. and II. was also determined by the "frame" hygrometer, two readings in each case. In No. I the absolute method gave a higher reading than the hygrometer; in II. the hygrometer gave the higher reading. Of course the two methods could not be used simultaneously in the same nest, hence in fairness we could compare only the averages. Averaging the two, the hygrometer gave 71.8, the absolute 70.8. Hence we must conclude that for earth nests at least the nest hygrometer is correct within the limits of experimental error. This is the test previously referred to in discussing the frame hygrometer. Looking now at the vapor pressure in the nests, we see that it is from $2\frac{1}{2}$ to 4 times as great as in the room during the same time.

ACTUAL HUMIDITY AND CIRCULATION.

Taking the actual humidities in nests and in incubators determined during this test as fairly representative of those during the season in the same kinds of nests and the same incubators run in the same way, let us place the results in juxtaposition for comparison.

TABLE XIX: EVAPORATION AS RELATED TO ACTUAL HUMIDITY IN NESTS AND IN INCUBATORS.

Incubator.	How treated.	Actual humidity as determined in August.	Evapo- ration.	Number of hatches of which evaporation is average.
Hens	Earth nest	70.8	9.7	3 hatches, May, June, July.
Hens	Straw nest	52.8	11.9	20 hatches, May, June, July.
Hens	Ventilat'd nest	35.0	14.5	2 hatches, June and July.
Model	Buttermilk	54.4	9.5	2 hatches. Large tray of buttermilk almost covering bottom of incubator.
No. I. 1907 Prairie State.	} Sand tray and water } Dry	46.2	9.6	10 hatches, moisture by sand tray and water.
No. III. " "				
No. IV. " "		21.3	14.5	7 hatches in 1907 Prairie State, dry.
No. II. " "				

Note that the humidity in earth nests was 25 per cent. greater than that in the Model, and 50 per cent. greater than in the moist Prairie States. And yet the evaporation in the earth nests was slightly the greater, in spite of the very high humidity! These facts, it seems to me, can have only one explanation, viz., a faster circulation in the nests than in the incubators. The whole table bears out this argument. This is the proof already referred to in discussing circulation. Putting into practice this season the conclusions we reached last year, Mr. Graham has been able to almost treble the performance of the dry machine with which we began in 1906. (See Table VII., page 27.) Zenoleum and water, chicks alive in 4 weeks = 44 per cent. of eggs set; dry machines, chicks = only 16.1 per cent. of eggs set. Still we have not yet overtaken the hen, who is able to give us 52 chicks 4 weeks old for every 100 eggs set. Perhaps proper circulation is the vitalizing power that must be combined with those already established to place artificial incubation abreast or possibly in advance of the natural process.

Carbon Dioxide in Relation to Incubation.

By C. C. THOM, DEMONSTRATOR IN PHYSICS.

Carbon dioxide is a colorless gas with an acid (sour) taste, and a more or less pungent odor. It is formed largely by the oxidation of carbonaceous organic matter, and is given off in considerable quantities by the lungs of the living animal during respiration. It is not a poisonous gas, although in an atmosphere containing large quantities of carbon dioxide death might result from suffocation or from want of oxygen. While carbon dioxide is not of itself injurious, yet it is a product of combustion and respiration usually accompanied with other injurious products, and the amount of it present in the atmosphere is taken as a standard by which we can judge of the quality or purity of the air. It is everywhere found in small quantities, from 3 to 4 parts in 10,000 in the atmosphere of the country.

Taking the atmosphere of the country as a standard of purity necessary to the proper maintenance of animal life, it was thought that possibly the air in the egg chamber of the incubator, during incubation, became so highly impregnated with carbon dioxide as to impair the healthy and normal development of the embryo chick. To test this theory it was decided to analyze the air in the egg chambers of a number of incubators for carbon dioxide. For this purpose a special apparatus was fitted up consisting (see Fig. 6) of a large aspirator, bottle A, so fitted and graduated that a definite volume of water could be drawn from it by opening the pinch-cock P, necessitating the same volume of air being drawn into the bottle to replace the water taken out. The air drawn in was taken from the egg chamber of the incubator by inserting the end of the rubber tube T through a small hole in the door of the incubator. The air drawn from the egg chamber was not allowed to pass directly into the large aspirator bottle, but was first made to pass through a known volume of a standard solution of potassium hydrate contained in the small bottle K, and in so doing all the carbon dioxide in the air was absorbed by the potassium hydrate uniting with it to form a potassium carbonate. In testing the solution in the small bottle K for potassium carbonate the following method was used:

To an aliquot portion of the solution was added a few drops of phenolphthalein indicator, and the excessive alkali neutralized with one-hundredth normal sulphuric acid, care being taken to keep the tip of the burette immersed in the solution to prevent the escape of any carbon dioxide. To the clear solution was then added a few drops of methyl orange indicator, and the solution again titrated with one one-hundredth normal sulphuric acid, until all the carbonate present had been broken up, as indicated by the change in color of the solution. From the amount of one one-hundredth normal acid used in the last titration, the volume of carbon dioxide in the volume of air taken from the incubator was determined. In figuring the results of these analyses no correction was

made for the change in temperature of the air drawn from the incubator, as it was found that the error from this source was inappreciable. Precaution was taken, however, to make a daily analysis of the stock solution of potassium hydrate for carbonate and the error arising from this source deducted from our results.

Numerous analyses were made of the air in the egg chamber and also of the air in the incubator room. At the same time many analyses

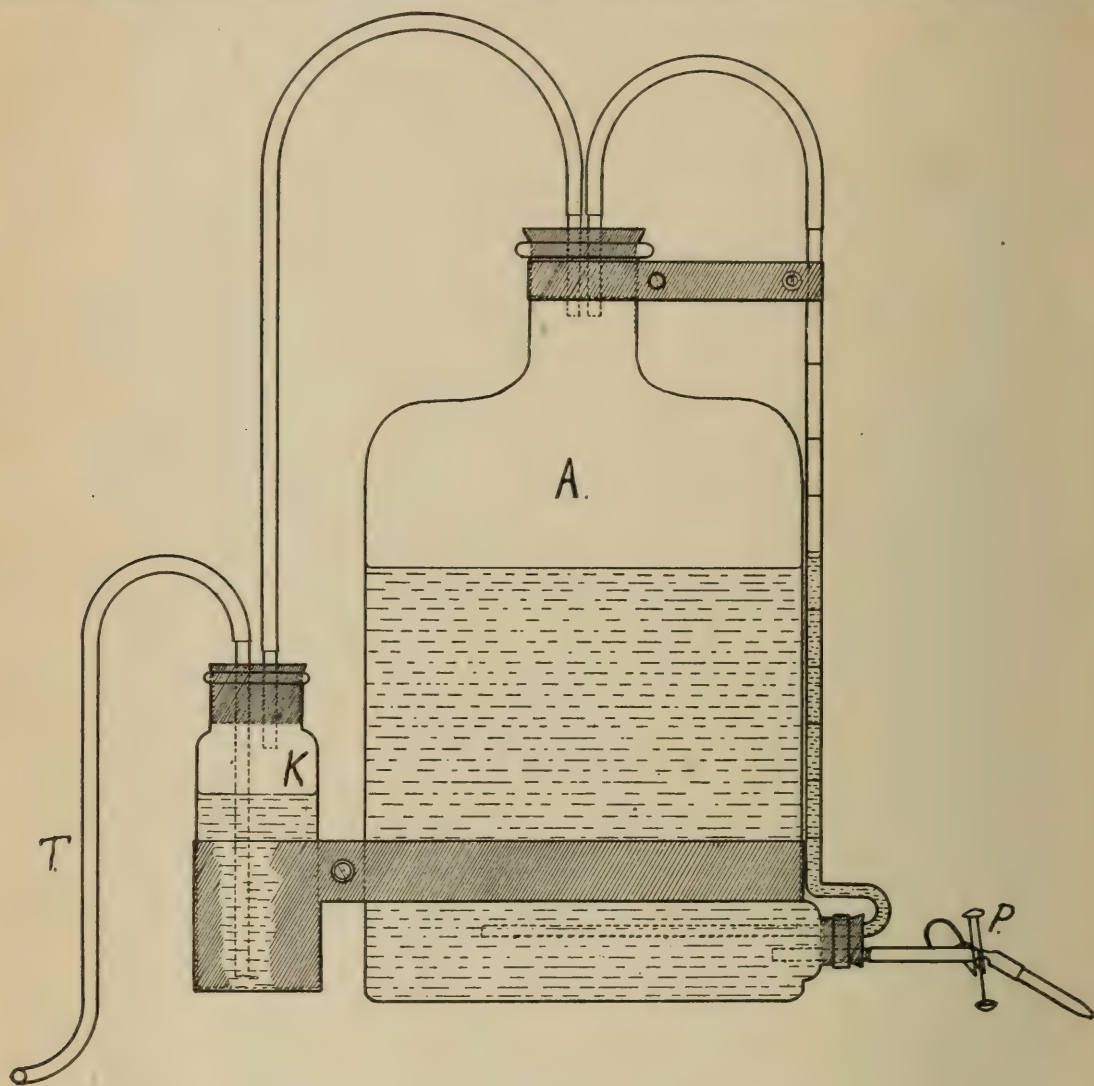


Fig. 6.

were made of the air from under setting hens. The results of these analyses show conclusively that while the air in the egg chamber is not nearly so pure as the air in the incubator room, it is still much purer than the air from under setting hens. The average of all the analyses of air from the incubator room shows 7 parts carbon dioxide in 10,000 parts of air. The air from the egg chamber of the incubators, run with and without moisture, shows an average of 9.90 parts carbon dioxide in 10,000; while the air from under setting hens shows on an average 31.93 parts

of carbon dioxide, more than three times the amount found in the incubators, and over four times the amount found in the incubator room.

The knowledge of this fact led to the belief that possibly a high carbon dioxide content of the air in the incubator chamber during incubation was necessary to a successful hatch. The results of analyses so far showed that increased moisture in the incubator gave a decided increase in carbon dioxide, from 9.15 parts in the dry machines to 10.46 parts in the machines run with moisture, or an increase of 1.31 parts. By referring to Table VII. (page 27) it will be noted that the vitality of the chicks from the hatches was increased from 16.1 per cent. in the dry machines to 32.7 per cent. in the wet machines.

Four hatches were then conducted, during which a pan of whole milk was kept in each machine. The results of these tests showed that while the carbon dioxide content of the machines was increased from 10.46 parts when the machines were supplied with pure water to 12.12 when the machines were supplied with whole milk, yet the mortality of the chicks hatched was considerably greater than when pure water alone was used. Buttermilk, however, gave much better results than whole milk, the carbon dioxide content was slightly decreased from 12.12 to 12.03 parts in 10,000, while the percentage of chicks alive at four weeks in per cent. of eggs set, was increased from 23.2 per cent. for whole milk and 32.7 per cent. for water to 37.4 per cent. for buttermilk. The increase in carbon dioxide in the machines run with buttermilk and whole milk was due to the emission of this gas during the fermentation of the milk which was inoculated with *Bacillus ærogenes lactis* before being put in the machine.

To determine to what extent, if any, these successful hatches with buttermilk were due to the comparatively high carbon dioxide content, machine 3 was fitted up with a gas pipe leading from a drum of artificial carbon dioxide through the fresh air intake to the interior of the machine, where the pipe was so arranged that the gas entering by it would be distributed uniformly throughout the egg chamber. Approximately 2,500 cc. of carbon dioxide was put into this machine twice daily—just after the eggs were turned in the morning and again just after they were turned in the evening. In all, three hatches were made in which artificial carbon dioxide was supplied. Moisture also was supplied during these hatches. The analysis of the air from this machine gave an average of 43.32 parts carbon dioxide in 10,000 of air. The live chicks at four weeks, from these hatches, in per cent. of eggs set, was 37.2, an increase of 4.5 per cent. over moisture only, and about equal to that of buttermilk. The increase in vitality of the chicks from the combination of carbon dioxide and moisture over moisture only, amounting as it does to 4.5 per cent. of the eggs set, seems directly due to the higher carbon dioxide content. At the same time buttermilk used as moisture and a comparatively low carbon dioxide content gave practically the same result. Again, when the moisture machines were disinfected with zenoleum, the average carbon

dioxide content in the egg chamber was decreased from 10.46 parts for water only to 8.29 parts for water and zenoleum, and from 9.15 parts in the dry machine to 5.86 parts in the dry machine disinfected with zenoleum. In every instance disinfecting with zenoleum resulted in a decrease of carbon dioxide, yet the use of zenoleum never failed to give a better hatch, and higher vitality. While a high carbon dioxide content seems decidedly beneficial in the case of machines supplied with moisture only, yet it is just possible that the function it performs in artificial incubation may be fulfilled by something else, as the results from the use of buttermilk and zenoleum seem to indicate.

Although the work on carbon dioxide is not conclusive, the results so far furnish much valuable data, and establish many useful relationships. Just what function, if any, carbon dioxide performs in incubation, and to what extent it is essential, is a point on which we have not at present sufficient experimental data to warrant conclusions.

TABLE XX. CARBON DIOXIDE UNDER SITTING HENS.

Hens	Volumes in 10,000 volumes of air								Average
Hen 2,235	26.7	20.0	28.9	24.5	26.7	20.00	24.5	24.5	24.48
" 532	35.6	33.4	35.6	35.6	33.4	37.8	33.4	.....	34.97
" 566	31.1	37.8	31.1	26.7	31.1	31.1	31.1	26.7	30.84
Hen on earth nest.....	35.6	35.6	.....	.....	.....	.....	.....	.....	35.6
" " flat ".....	44.5	37.9	33.3	37.8	37.8	33.3	35.6	.....	37.17
" in Incubator.....	22.2	24.5	22.2	22.2	26.7	26.7	.....	.....	24.08
Hen 5,257	28.9	31.1	35.5	.....	.....	.....	.....	.....	31.83
" 274	33.4	37.8	37.8	.....	.....	.....	.....	.....	36.33
" 642	28.9	33.3	40.0	33.4	.....	.....	.....	.....	33.9
" 81	37.8	*40.0	.....	.....	.....	.....	.....	.....	38.9
Hen under brooder....	33.4	48.9	40.0	42.2	44.5	.....	.....	.....	41.8
Hen 31.....	35.5	31.1	.....	.....	.....	.....	.....	.....	33.3
" 605.....	24.5	22.2	31.1	.....	.....	.....	.....	.....	25.93
" 578.....	28.9	26.7	.....	.....	.....	.....	.....	.....	27.8
White Rock	31.1	.....	.....	.....	.....	.....	.....	.....	31.1
Hen A 1.....	35.5	31.1	35.1	31.1	26.7	.....	.....	.....	31.9
" A 2.....	35.1	35.6	33.5	40.0	.....	.....	.....	.....	36.05
" A 3.....	26.6	28.9	33.3	28.9	.....	.....	.....	.....	29.43
" A 4.....	31.1	31.3	33.4	35.5	.....	.....	.....	.....	32.83
" A 5.....	26.6	37.8	26.6	31.1	.....	.....	.....	.....	30.53
" A 6.....	28.9	33.4	37.8	35.6	28.9	.....	.....	.....	32.92
" A 7.....	28.9	26.6	26.6	28.9	42.2	.....	.....	.....	30.64
" A 8.....	26.7	28.9	33.3	35.6	31.1	.....	.....	.....	31.12
" A 9.....	33.3	35.5	35.5	31.1	33.3	.....	.....	.....	33.74
" A10.....	28.9	28.9	33.3	31.1	35.6	.....	.....	.....	31.56
" A11.....	24.4	28.9	28.9	28.9	31.1	.....	.....	.....	28.44
" A12.....	26.68	24.46	24.46	24.46	.....	.....	.....	.....	25.02

* 20th day.

TABLE XXI. CARBON DIOXIDE IN INCUBATORS.

Machine showing condition	Date set	Volumes in 10,000 volumes of air.							Aver age-
<i>Machine 1</i>									
Water	April 26....	10.00	10.00	10.00	9.45	.....	.....	9.86	
Dry.....	April 3.....	3.34	7.78	7.78	7.78	.....	.....	6.67	
Moisture, Fumes.....	May 21.....	50.04	56.34	61.16	.....	.....	.....	55.85	
Dry, Fumes	June 17 and	53.37	55.60	62.72	61.16	.....	.....	58.21	
	July 18.....								
<i>Machine 2</i>									
Whole Milk.....	April 3... {	11.12	12.23	10.00	11.12	11.12	13.34	} 11.46	
		9.45	13.34	.....	.....	.....	.....		
Dry	April 26....	11.12	10.00	11.12	10.00	8.89	.....	10.23	
Water, Zenoleum.....	May 21.....	8.89	9.45	10.00	8.89	10.00	.....	9.45	
Whole Milk, Zenoleum	June 17.....	11.12	13.34	8.89	.....	.....	.....	11.11	
Dry.....	July 18... {	8.89	7.78	9.45	10.00	7.78	7.78	} 8.73	
		9.45	.....	.....	.....	.....	.....		
<i>Machine 3</i>									
Buttermilk	April 3... {	13.34	15.56	15.56	11.12	16.68	13.34	} 13.34	
		11.12	10.00	.....	.....	.....	.....		
Whole Milk.....	April 26....	12.23	13.34	13.34	12.23	.....	.....	12.79	
Water and CO ₂	May 21.....	26.68	22.24	41.13	50.04	.....	.....	35.02	
Water, CO ₂ , Zenoleum	June 17.....	41.13	61.16	55.60	62.72	.....	.....	55.16	
Water, CO ₂	July 18.....	55.60	41.13	48.92	60.04	.....	.....	51.42	
<i>Machine 4</i>									
Water	April 3.....	6.72	7.78	7.78	6.72	6.72	7.78	7.25	
Buttermilk	April 26....	11.12	12.23	10.67	10.00	.....	.....	11.01	
Dry, Zenoleum	May 21.....	5.56	4.45	6.72	6.72	.....	.....	5.86	
Water, Zenoleum.....	June 17.....	7.78	5.56	6.72	.....	.....	.....	6.69	
Water, Zenoleum.....	July 18.....	6.72	6.72	6.72	8.89	.....	.....	7.26	
<i>Hearson</i>									
Moistare	April 3	11.12	12.23	17.79	11.12	13.34	13.34	} 13.16	
	April 26	13.34	13.34	13.34	13.34	13.34	17.79		
	May 21	12.23	11.12	13.34	11.12	.....	.....		
Buttermilk	June 17.....	17.79	13.34	17.79	16.68	13.34	.....	15.79	
<i>Open Bottom Prairie State</i>									
Water, Milk, Zenoleum	April 11....	6.67	8.89	.....	.....	.....	.....	7.78	
Dry—Eggs in galvanized tray.....	May 6.....	12.23	10.00	12.23	12.23	6.67	.....	10.67	
<i>Model</i>									
Moisture, (sprinkled) Zenoleum	April 11....	8.89	.....	.....	.....	.....	.....	8.89	
Moisture.....	May 6.....	7.78	6.67	8.89	.....	.....	.....	7.78	
Buttermilk	July 18.....	10.00	11.12	10.00	12.23	8.89	7.78	10.00	
<i>Peerless</i>									
Dry.....	March 23 and	8.89	8.89	10.67	8.89	.....	.....	9.33	
	April 16.....								
Buttermilk	May 11.....	10.00	11.12	8.89	.....	.....	.....	10.00	
Moisture, Zenoleum....	June 11.....	10.00	8.89	7.78	10.00	.....	.....	9.16	

CARBON DIOXIDE IN INCUBATORS—*Concluded.*

Machine showing condition.	Date set.	Volumes in 10,000 volumes of air.							Average.
<i>1906 Cyphers</i>									
Moisture.....	April 16	10.00	7.78	.....	.....	.....	.....	.....	8.89
Slightly moist Zenoleum	May 11.....	10.67	8.89	5.56	7.78	.....	.....	.....	8.22
<i>1905 Cyphers</i>									
Dry Zenoleum.....	April 11.....	5.56	5.56	.....	.....	.....	.....	.....	5.56
Dry	May 6.....	8.89	10.00	8.89	.....	.....	.....	.....	9.26
<i>Cortland</i>									
Buttermilk	May 6.....	5.56	8.89	8.89	12.23	.....	.....	.....	8.89
<i>Continuous</i>									
Moisture	June 11.....	10.00	12.23	11.12	9.45	.....	.....	.....	10.70
Incubator Room.....	{ April 16 to July 25.....	8.89	7.78	7.78	4.45	11.12	7.78	.....	7.00
		3.34	.....	7.78	5.54	5.54	.....		

TABLE XXII. CARBON DIOXIDE—VOLUMES IN 10,000 VOLUMES OF AIR—AVERAGE RESULTS.

Hens.

Earth nest	35.6
Flat nest	37.14
Ventilated nest (hen in incubator)	24.08
All hens	31.93

Machines.

Dry, lamp fumes	58.21
Moisture, lamp fumes	55.85
Moisture, carbon dioxide and zenoleum	55.16
Moisture and carbon dioxide	43.22
Whole milk	12.12
Buttermilk	12.03
Whole milk and zenoleum	11.11
Moisture only	10.46
Dry	9.15
Moisture and zenoleum	8.29
Water, milk and zenoleum	7.78
Dry, zenoleum	5.86
Incubator room	7.00

Chemical Work in Connection With Incubation Problems.

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The chemical work herein reported was undertaken with the object of gaining some definite information regarding the distribution of the mineral constituents in the different parts of the egg, and to determine the effect of different methods of incubation on the amount of these constituents absorbed by the chick. Previous investigations carried on in the department of Physics of this institution demonstrated the fact that there was a large quantity of carbon dioxide gas around the eggs during incubation by the hen. It is well known that carbon dioxide in the presence of moisture will dissolve calcium carbonate and that the shell of the egg is composed largely of this substance; consequently, the question naturally arises, has the presence of this gas anything to do with the greater vitality of the chicks incubated by the hen? This hypothesis was further strengthened by the observed fact that, although the percentage of eggs hatched was small, the chicks obtained from incubators in which lamp fumes were present were generally strong and vigorous. It was hardly thought that the humidity of the air under the hen or in the incubator was sufficient to allow the carbon dioxide to dissolve any appreciable amount of the lime, yet it was thought that the point was worth investigating.

The plan of our investigation was to determine the amount of lime (CaO) and phosphoric acid (P_2O_5) in a number of eggs from several hens, and then to ascertain the amount of these constituents in the chicks got by different methods of incubation from the eggs of the same hens. As it would, obviously, be impossible to analyze an egg and to get a chick from the same egg, we had to analyze a number of eggs from each of several hens and thus obtain figures that would be approximately correct for comparison in the after work.

METHOD OF ANALYSIS.

An outline of the methods employed in separating the different parts of the egg and of making the analysis is as follows:

Proportion of Shell, White, and Yolk. This part of the work required no special skill, since the different parts were separated in a strictly mechanical way. The egg was first freed of all adhering foreign matter as completely as possible, and then weighed. The parts were next separated and placed in tarred dishes and weighed, their total weight being checked with the original weight obtained.

As our object in studying the composition of the original egg was to obtain figures with which to compare the composition of the chick

after incubation, the membrane lining the shell was included with the latter, since this membrane is not absorbed by the chick, but left behind. The white was drained from the shell as completely as possible, while the chalaza, which is that part of the white that joins it to the yolk, was clipped off with a pair of sharp scissors as near as could be without injuring the yolk.

A very convenient way of separating the white from the yolk was by making an opening in the shell, just large enough for the white to stream through, and yet small enough to withhold the yolk. After the white was all out, the opening was enlarged enough to allow the escape of the yolk. Rapid separation could be made in this way.

Calcium and Phosphorus in the different parts of the Egg. Methods of making solution: Since phosphorus is volatile* and cannot be determined by incineration and examination of the ash, all the solutions were made in the wet way, using strong nitric acid as the oxidizing agent.

Shell, this being largely of calcareous nature, readily goes into solution on treatment with strong hydrochloric acid. The broken shell was placed in a beaker, covered with a watch glass to prevent loss during the vigorous effervescence due to the escape of carbon dioxide, and the acid gradually added, till most of the carbonate was attacked, after which solution was completed by gentle heating. At this stage nothing is left undissolved, except the lining membrane, which is easily oxidized and decomposed by boiling the solution for half an hour with 1 or 2 cubic centimeters of strong nitric acid. When solution was effected, the whole was made up to a volume of 250 cc. and aliquot parts of this taken for the several estimations.

White and Yolk. Since the greater part at least of the calcium and phosphorus is present in the white and yolk of the egg in an organized condition, it is necessary that a complete disorganization be accomplished in order that these elements be liberated and brought into a condition from which they can be isolated by the precipitating reagent, which is used in their estimation. Carius† has found that the phosphorus of organic material can be completely removed by oxidizing the substance with strong nitric acid; while in our work here, by comparing with the ashing method, it was found that the method which removed phosphorus removed the calcium also. Consequently, we used nitric acid for oxidizing the phosphorus, and the solution thus obtained was also utilized for the determination of calcium.

As the phosphorus of both the white and yolk is probably present in combination with proteids, bodies which are comparatively easily oxidizable, we carried out the digestion with nitric acid in the ordinary Kjeldahl

*V. Barmbauer found that Vitellin, which, when treated with nitric acid, gives 3 per cent. of phosphoric acid, yields barely 0.3 per cent. of ash. (Fresenius, Vol. II., p. 120, COHN.)

†Fresenius, Vol. II., p. 116, COHN.

digestion flasks used in nitrogen estimations. A small quantity of hydrochloric acid‡ was also used to hasten the liberation of oxygen from the nitric acid. As the nitric acid became exhausted more was added from time to time. After about one hour's digestion solution was usually effected and nothing but the elaidin formed from the fats was left. This latter was easily filtered off and then the solutions were made up to a volume of 250 cc. with water.

DETERMINATIONS.

Calcium : Aliquot parts of the solution were used, and the calcium precipitated with ammonium oxalate and determined in the usual way.

Phosphoric acid (P_2O_5) : Aliquot parts were used from which the hydrochloric acid was expelled by repeated evaporation with nitric acid. The phosphoric acid was then determined volumetrically, as outlined in Methods of Analysis under Optional Volumetric Method, p. 13.

Calcium in the Chick : The contents of the egg (the chick) after incubation were not examined for phosphorus and the method of extracting the calcium was changed for one which was not quite so exacting on time and material. The shell and membrane were completely removed and discarded.

Method of Making Solution : The chick was placed in a porcelain dish and incinerated more or less completely. Complete carbonization is as far as the process need be carried, for at that stage all mineral constituents are freed from their organic combinations. After combustion the contents of the dish were pulverized and extracted with successive portions of strong hydrochloric acid until exhaustion was complete. The different extracts were then combined and made up to a volume of 250 cc. with water.

Determination : Aliquot portions of the solution were pipetted off, treated with a small quantity of ferric chloride to remove phosphoric acid, neutralized with ammonia and the ferric phosphate and ferric hydrate filtered off and washed. Calcium was precipitated from the combined filtrate and washings with ammonium oxalate and estimated in the usual way.

The results obtained are as follows :

‡Methods of A.O.A.C., A under total phosphoric acid in fertilizers, p. 12.

TABLE XXIII. LIME AND PHOSPHORIC ACID IN DIFFERENT EGGS FROM THE SAME HEN.

Egg No.	Total weight of egg.	Percentage weight of			Per cent. of phosphoric acid (P_2O_5) in			Per cent. of lime (CaO) in		
		Shell.	White.	Yolk.	Shell.	White.	Yolk.	Shell.	White.	Yolk.
17.....	66.02	13.5	54.4	32.1	.2576	.0185	.8000	39.89	.0269	.....
	63.74	14.2	55.9	29.9	.....	.....	.8306	.....	.....	.1992
	62.16	13.9	55.3	30.8	.3090	.0058	.....	38.23	.0073	.....
	62.90	13.1	57.5	29.4	.....	.0083	.4144	.....	.0159	.2276
	64.33	12.9	56.8	30.3	.....	.0069	.6168	.....	.0165	.1684
Average.....	63.83	13.5	56.0	30.5	.2833	.0099	.6155	39.06	.0167	.1984
360.....	52.65	14.1	53.2	32.7	.2547	.0165	.7881	36.44	.0312	.1946
	51.26	12.6	52.3	35.1	.3703	.0076	.6810	40.10	.0113	.2054
	49.48	12.9	53.0	34.1	.3375	.0194	.3900	43.17	.0223	.1896
	47.61	12.6	53.0	34.1	.2912	.0060	.5745	40.63	.0109	.1753
Average.....	50.85	13.1	52.8	34.1	.3134	.0124	.6084	40.09	.0189	.1912
40.....	54.80	12.4	53.3	34.3	.1909	.0104	.6899	41.98	.0138	.2072
	54.75	12.8	52.6	34.6	.1991	.0102	.7074	41.66	.0135	.1894
	50.94	13.0	50.7	36.3	.2639	.0098	.4475	41.67	.0235	.1697
	57.41	11.9	52.6	35.5	.2256	.0100	.5966	42.24	.0083	.1774
	52.60	13.6	53.9	32.5	.2686	.0268	.4884	41.07	.0223	.....
	55.43	12.6	52.4	35.0	.2155	.0087	.8156	42.18	.0191	.1718
Average.....	54.32	12.7	52.6	34.7	.2273	.0127	.6242	41.80	.0168	.1831
356.....	45.14	12.1	52.8	35.1	.3174	.0107	.8120	38.06	.0127	.1781
	43.39	12.0	51.0	37.0	.3352	.0138	.6151	39.99	.0148	.1473
Average.....	44.27	12.1	51.9	36.1	.3263	.0123	.7136	39.03	.0138	.1627
249.....	53.63	11.6	59.8	28.6	.2162	.0175	.9062	37.53	.0253	.....
	53.51	12.2	59.7	28.1	.2676	.0121	.8359	40.90	.0403	.2240
	51.07	12.3	60.4	27.3	.2531	.0129	.8055	37.79	.0414	.1984
	43.03	9.6	65.3	25.1	.2289	.0109	.7149	34.69	.0288	.1165
	47.25	13.3	60.7	26.0	.3492	.0142	.5850	40.09	.0381	.1535
Average.....	49.70	15.8	61.0	27.0	.2630	.0135	.7495	38.20	.0348	.1981
805.....	50.54	14.8	52.1	33.1	.3146	.0194	.9137	36.37	.0290	.....
	50.60	13.7	55.7	30.6	.3170	.0200	.7888	38.96	.0178	.2161
	49.65	12.3	55.6	32.1	.3600	.....	.7610	38.51	.....	.1799
	47.80	13.1	55.4	31.5	.3520	.0095	.6160	39.53	.0076	.2034
	47.93	12.9	55.1	32.0	.3698	.0096	.5256	41.38	.0248	.1706
	52.60	13.1	56.3	30.6	.3116	.0103	.6609	39.84	.0196	.1783
Average.....	49.89	13.3	55.0	31.6	.3375	.0138	.7110	39.10	.0198	.1897
696.....	51.32	11.8	55.6	32.6	.3459	.0257	.9475	39.37	.0237	.....
	55.29	11.5	53.3	35.2	.3832	.0136	.7130	45.48	.0085	.1945
	52.76	12.6	52.8	34.6	.4274	.0127	.4155	41.82	.0209	.2188
	56.29	11.6	54.8	33.6	.3067	.0082	.4936	41.94	.0179	.2188
	50.78	12.6	53.5	33.9	.3203	.....	.8569	41.33	.....	.1927
Average.....	53.29	12.0	54.0	34.0	.3567	.0151	.6853	41.99	.0175	.2162
517.....	56.75	11.6	60.3	28.1	.3404	.0187	.8622	38.15	.0261	.....
	68.09	10.5	59.7	29.8	.3295	.0187	.7454	38.66	.0279	.1420
	64.94	12.5	59.0	28.5	.2573	.0092	.....	39.44	.0164	.....
	68.83	11.3	63.8	24.9	.2445	.0103	.4435	37.08	.0229	.1521
	67.78	12.6	64.2	23.2	.2229	.0127	.5569	37.19	.0353	.1471
Average.....	65.28	11.9	61.4	26.9	.2609	.0139	.5216	38.10	.0257	.1471

The eggs were, with the exception of Nos. 17 and 517, rather under the average weight, and they were not uniform in weight. The greatest variation appears to be in the quantity of shell, although this may be partly due to the fact that, while the white of the egg was drained away as completely as possible, the shell was not washed to remove the last traces of the albumen. This may also account for the slightly high proportion of shell.

Regarding the distribution of the phosphoric acid and lime, it is evident that the yolk contains the largest proportion of the phosphoric acid, and the shell the most lime, while, as would naturally be expected, the white of the egg contains but little of these constituents.

To bring out more clearly the average weight of the eggs and the distribution of the lime and phosphoric acid in the several parts, the average results obtained from the analyses of the different eggs from the same hen are given in the following table:

TABLE XXIV. AVERAGE PERCENTAGE AMOUNT OF LIME AND PHOSPHORIC ACID IN EGGS FROM DIFFERENT HENS.

Egg No.	Total weight of egg.	Percentage weight of			Per cent. of phosphoric acid in			Per cent. of lime in		
		Shell.	White.	Yolk.	Shell.	White.	Yolk.	Shell.	White.	Yolk.
17	63.83	13.5	56.0	30.5	.2833	.0099	.6155	39.06	.0167	.1984
360	50.85	13.1	52.8	34.1	.3134	.0124	.6084	40.09	.0189	.1912
40	54.32	12.7	52.6	34.7	.2273	.0127	.6242	41.80	.0168	.1526
356	44.27	12.1	51.9	36.1	.3263	.0123	.7136	39.03	.0138	.1627
249	49.70	15.8	61.0	27.0	.2630	.0135	.7495	38.20	.0348	.1981
805	49.89	13.3	55.0	31.6	.3375	.0138	.7110	39.10	.0198	.1897
696	53.29	12.0	54.0	34.0	.3567	.0151	.6853	41.99	.0175	.2162
517	65.28	11.9	61.2	26.9	.2609	.0139	.5216	38.10	.0257	.1471

The above average results show extremes of from 44.27 to 65.28 grams in the average weight of eggs for different hens, a difference of over 21 grams, and a variation of nearly 10 per cent. in the amount of the white of the egg.

The following table shows the absolute average weights of the different parts of the eggs and of the phosphoric acid and lime in the shell and in the contents, that is, in the yolk and white combined:

TABLE XXV. AVERAGE WEIGHT OF EGGS AND THE PHOSPHORIC ACID AND LIME IN SHELL AND CONTENTS (grams).

Egg No.	No. of analysis.	Average weight of egg.	Average weight of			Average P_2O_5 in		Average CaO in	
			Shell.	White.	Yolk.	Shell.	Contents.	Shell.	Contents.
17	5	63.83	8.64	35.75	19.44	.0248	.1353	3.431	.0436
360	4	50.85	6.58	26.57	17.09	.0205	.1052	2.622	.0378
40	6	54.32	6.91	28.75	18.65	.0157	.1205	2.891	.0337
356	2	44.27	5.34	22.98	15.94	.0174	.1114	2.032	.0285
249	4	49.70	6.35	30.89	14.13	.0222	.1164	2.483	.0312
805	6	49.89	6.65	27.44	15.59	.0223	.1149	2.594	.0349
696	5	53.29	6.40	28.79	18.09	.0229	.1270	2.691	.0431
517	5	65.28	7.65	40.74	17.49	.0196	.1187	2.908	.0364

The above data show that the lime in the contents of the egg varies from a little less than .03 grams to over .04 grams, a very small amount to supply all the lime necessary for the formation of bone in the young chick.

To ascertain the absolute weight of lime in the chick at different stages of the period of incubation, we took eggs from the incubators eleven days and twenty days from the commencement of incubation and determined the amount of lime in the partially developed and fully developed chick. It was soon found that after eleven days of incubation there was practically the same amount of lime in the partially developed chick as there was in the contents of the original egg, but that at the end of the incubation period there was a very decided increase. The eggs used in this part of the work in the June hatch were from the same hens as the eggs analyzed earlier in the season. It was impossible to secure eggs from the same hens for the study of the July hatch, but there is such a wide difference between the average lime content of the fresh egg and that of the young chick at the end of incubation period that it does not seriously affect the results. Unfortunately we were unable to take up the work of determining the lime content of the chicks until so late in the season that we could not study more than one hatch with each incubator. Consequently, the results obtained are not so reliable and conclusive as if a number of hatches with each method of incubation could have been examined. However, some very interesting facts have been ascertained, and the work will be continued another year. The following table gives the results obtained so far:—

TABLE NO. XXVI. WEIGHT OF LIME IN CHICK AT DIFFERENT PERIODS OF INCUBATION.

No. of Egg.	Name of Incubator.	Treatment.	Period of Incubation.	Total Lime (CaO) in contents.	Remarks.
<i>June Hatch.</i>					
360	Cyphers	Dry	11 days	.0340	
17	"	"	11 "	.0372	
696	"	"	11 "	.0385	
360	"	"	20 "	.1804	
527	"	"	20 "	.1707	
696	"	"	20 "	.1877	
527	Peerless	Dry, hot water machine	11 "	.0390	
527	"	"	11 "	.0385	
527	"	"	20 "	.1830	
527	"	"	20 "	.1267	Apparently weak.
696	"	"	20 "	.1697	
696	"	"	20 "	.1830	
40	"	"	20 "	.1367	
40	"	"	20 "	.1462	
517	Continuous Hatcher	A small amount of moisture	20 "	.1580	
805	"	"	20 "	.1462	
805	"	"	20 "	.1650	
360	"	"	20 "	.1482	
360	"	"	20 "	.1822	
517	Hen	"	20 "	.2017	
517	"	"	20 "	.1940	
360	"	"	20 "	.2042	Yolk absorbed, chick half out of shell.
360	"	"	20 "	.2030	Yolk absorbed, chick picking.
360	"	"	20 "	.2017	Yolk absorbed.
360	"	"	20 "	.2000	
40	"	"	20 "	.1137	Apparently weak, yolk not absorbed, brownish yellow in color, thin and watery.
40	"	"	20 "	.1197	
40	"	"	20 "	.1584	
440	"	"	20 "	.1710	
<i>July Hatch.</i>					
195	Model	Buttermilk in moisture pan	20 "	.2182	Nearly out of shell, yolk absorbed.
93	"	"	20 "	.1820	
590	"	"	20 "	.1860	
502	"	"	20 "	.2157	Not a strong looking chick hatched.
476	"	"	20 "	.1227	
164	"	"	20 "	.2217	
57	Prairie State	Lamp fumes, dry	20 "	.1927	
502	"	"	20 "	.2202	
590	"	"	20 "	.1972	
311	"	"	20 "	.1935	Yolk absorbed.
93	"	"	20 "	.1985	
84	"	"	20 "	.2312	
93	"	Dry	20 "	.2150	
311	"	"	20 "	.2157	

TABLE NO. XXVII. WEIGHT OF LIME IN CHICK AT DIFFERENT PERIODS OF INCUBATION—*Continued.*

No. of Egg.	Name of Incubator.	Treatment.	Period of Incubation.	Total Lime (CaO) in contents.	Remarks.
57	Prairie State	Dry	20 days	.1950	
476	"	"	20 "	.1817	
693	"	"	20 "	.1717	
157	"	"	20 "	.1792	
476	"	Artificial CO ₂ , H ₂ O used as moisture	20 "	.2150	
502	"	"	20 "	.2262	
311	"	"	20 "	.2162	
662	"	"	20 "	.1647	
157	"	"	20 "	.1982	
84	"	"	20 "	.1727	
195	"	Disinfected with Zenoleum, H ₂ O used as moisture	20 "	.2175	
520	"	"	20 "	.2070	
476	"	"	20 "	.1955	
590	"	"	20 "	.2062	
311	"	"	20 "	.2142	
93	"	"	20 "	.2052	
662	Hen	.....	20 "	.2330	
662	"	.....	20 "	.2327	
157	"	.....	20 "	.1560	
93	"	.....	20 "	.1592	
476	"	.....	20 "	.2065	
590	"	.....	20 "	.1832	
311	"	.....	20 "	.2010	
164	"	.....	20 "	.2175	
84	"	.....	20 "	.1787	
613	"	.....	20 "	.2152	
613	"	.....	20 "	.2280	

As each chick was taken from the shell notes were made on its apparent strength. It will be observed that in every case where the chick was marked as "weak" there was a very low absorption of lime, and where it was noted as being unusually strong, there was a large absorption. In this case only decided differences in appearance were noted, but in view of the above result more careful notes will be made in future work. In this connection it may be noted that the lime content of the chicks of the June hatch is lower than that of the July hatch, and Mr. Graham of the Poultry department reports that the chicks of the former month were inferior in vitality.

It is very probable that there is a vital force in the egg which imparts vitality to the chick. For instance, egg No. 360 in nearly every case produced a chick with a high lime content, and egg No. 40 in every case gave a chick with a low lime content, and three of them were noted as being unusually weak.

It is also quite probable that the method of incubation has something to do with the lime content of the chick and possibly with the vitality of the chick. The five chicks from the Continuous Hatcher were, with one exception, low in lime, and it was found that these chicks did not thrive well; while all the chicks from the Prairie State machine, in which there were lamp fumes, were high in lime and were strong and thrifty.

From what has been noted in the two preceding paragraphs, it is quite evident that, in order to get results which shall give a strictly fair and comparable basis on which to compare the merits of different methods of incubation, a series of eggs must be selected such that it is possible to have them appear in each incubator. It is also indicated, when the June and July hatch are compared, that it is quite necessary to select this series of eggs in as nearly the same season of the year as possible, or, in other words, that fresh eggs should be selected for setting.

The following table has been prepared to show the average lime content of the chicks from the different methods of incubation, the amount of carbon dioxide present, the percentage hatch, and the vitality of the chicks as indicated by the percentage number alive at the end of four weeks. In making up the average weight of lime in the chick all amounts below .1600 grams have been discarded; because all chicks containing less than that amount of lime were abnormally weak.

TABLE No. XXVIII. AVERAGE WEIGHT OF LIME IN CHICKS WITH DIFFERENT METHODS OF INCUBATION.

Method of Incubation.	Lime (CaO) content of chick, grams.	Carbon dioxide (CO ₂) in 10,000 parts, grams.	Per cent of hatch to fertile eggs.	Per cent chicks alive at end of four weeks cal. to fertile eggs.
<i>June Hatch.</i>				
Cyphers, dry	.1796	8.22	46.1	23.05
Peerless, dry, hot water machine.....	.1786	9.16	60.2	52.85
Continuous Hatcher. A little moisture.....	.1736	10.70	58.0	53.0
Hen	*.1966	.....	.....	.....
<i>July Hatch.</i>				
Model, buttermilk	.2047	10.0	65.3	53.09
Prairie State, lamp fumes, dry	.2056	58.21	43.5	36.5
Prairie State, dry	.1930	8.73	49.8	30.07
Prairie State, artificial CO ₂ and H ₂ O used as moisture	.1988	51.42	57.08	49.1
Prairie State, zenoleum and moisture	.2076	7.26	62.0	54.0
Hen	*.2106	.....	.....	.....
Average of hens set during whole season.....	.....	31.93	66.0	55.1

*All eggs used for analyses.

On looking over the above table it will be seen that the average lime content of chicks got by different methods of incubation was lower in June than in July, but in both months the chicks from the hen show the largest amount. There is apparently no connection between the amount of lime absorbed by the chick and the amount of carbon dioxide surrounding the egg during incubation. It has been found that large amounts of carbon dioxide are given off from the egg itself during incubation, and it is very probable that the gas from this source would have a greater dissolving effect upon the carbonate of the shell than that in the surrounding atmosphere. This would be true, because it is acting in the presence of liquid moisture.

While we do not wish to draw any definite conclusion on the comparatively small amount of work which has as yet been done, still we think it worthy of note that there appears to be some relation between the lime content of the chick and its vitality, as indicated by the per cent. of chicks alive at the end of four weeks. Where lamp fumes were used there is an apparent exception to this, as the percentage vitality is low. This may be explained, however, by the fact that wherever this method of incubation has been used the percentage hatch is low; but, at the same time, these chicks are always strong and vigorous. It may also be noted that the Continuous Hatcher gave chicks low in lime, and of a high vitality, yet, while a large percentage of these chicks lived through the four weeks' period, they did not prove to be thrifty, thus further bearing out our previous tentative statement, that there is a marked relationship between lime content and vitality.

We are not prepared, with the insufficient data which we have at hand, to give the above hypothesis with reference to the relationship between lime content and vitality as a definite conclusion, nor to state what conditions in incubation will cause the maximum absorption of lime; but we feel that the point is worthy of further study.

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

LEGUME BACTERIA.

SEED INOCULATION BY CANADIAN FARMERS
IN 1906 AND 1907.

BY S. F. EDWARDS AND B. BARLOW.

To maintain and increase the fertility of his land, the farmer must put back into the soil as much plant food as he removes in his crops. It is true that most soils contain rich stores of plant food, and that through tillage and the biological agencies in the soil this food is placed at the disposal of plants. This supply is by no means inexhaustible, and as it is removed from the soil by successive cropping, methods must be adopted to compensate for the loss. Phosphorus, potash, and nitrogen may be applied to the soil in the form of commercial fertilizers or as barnyard manure. Nitrogen may also be secured from the vast supply in the atmosphere through the associative action of legumes (plants belonging to the bean family), and certain bacteria of the soil. These bacteria have the power to penetrate the roots of seedlings of leguminous plants, to multiply there, and in association with the plant, in some manner not yet fully understood, to take nitrogen from the air and store it up in the plant. Such plants when plowed under naturally increase the nitrogen content of the soil. Evidence of the activity of these bacteria may be seen in the small nodules or tubercles which form on the roots of these plants. (See Fig 1). Not all plants belonging to the order Leguminosæ are thus affected, but only those belonging to the sub-order *Papillionaceæ*. Of these, the commonly cultivated ones which man uses are: The clovers, alfalfa or lucerne, sweet white clover, lupines, vetches, beans, soy beans, peas, lentils, locust, sweet pea, and winter flat pea. Many others of the same order grow wild in meadow and forest.

This enrichment of the soil by the aid of the legumes is by no means a new thing. The phenomenon has been known for centuries, some of the earliest writers having dilated upon the manurial value of legumes. Only in recent years, however, have we attained knowledge of the bacteria associated with the legumes, and of their importance in the process of assimilation of atmospheric nitrogen. Although the bacteria can, under certain conditions, accumulate the nitrogen of the air apart from the legume, the legume *cannot* take the nitrogen from the air without the presence of the bacteria in its roots.



Fig. 1.—Red Clover. Inoculated and not inoculated. Fleming, Sask.

Methods have been devised whereby the bacteria infecting the common legumes may be distributed to farmers to inoculate the seed. In the United States, the Department of Agriculture began the distribution of

cultures in 1902, and have continued it each season. Commercial firms have engaged in the manufacture and sale of such cultures.



Fig. 2.—Alsike Clover. Inoculated and not inoculated.
Fleming, Sask.

DISTRIBUTION OF CULTURES IN CANADA.

The Bacteriological Department of the Ontario Agricultural College began the distribution of cultures to Canadian farmers in the spring of 1905, and during that season two hundred and forty-six cultures were sent out. A circular letter was sent to all who had received cultures, asking for a report of the success or failure of the experiment. These results were received and tabulated by Harrison and Barlow, and published with a short historical account and discussion as Bulletin No. 148 of the Ontario Agricultural College.

During the season of 1906, cultures were again sent out from this laboratory, three hundred and seventy-five being distributed as follows :

Ontario	121	Quebec	5
Nova Scotia.....	108	New Brunswick	4
United States.....	60	British Columbia	4
Alberta	24	South Africa	4
Manitoba	19	Porto Rico	1
Saskatchewan	14	England	1
P. E. Island	10		

As in the previous year, blanks were sent to recipients of the cultures, asking for a report as to their success or failure with the experiment.

The cultures sent to applicants in Nova Scotia were sent in the name of the Nova Scotia Agricultural College, and the reports were sent to Principal Cumming of that school.

All experimenters found the culture easy to apply, and a large number expressed a wish to continue the experiment.

A summary of the reports received follows :

Province.	Crop Grown.		Result.	
			Benefit.	No Benefit.
Ontario	Alfalfa.....	12	9	3
	Red Clover...	14	10	4
	Peas.....	14	9	5
	Beans	11	6	5
	Soy Beans....	3	2	1
	Alsike.....	1	1	.....
	Vetch.....	1	1	.....
	Sweet pea....	1	1	.....
Alberta.....	Alfalfa.....	13	6	7
	Red Clover...	3	1	2
	Peas.....	1	1	.....
Saskatchewan.....	Alfalfa.....	1 .....	.....	1
	Red Clover...	2 .....	.....	2
	Peas	1	1	.....
	Beans	1 .....	.....	1
	Vetch.....	1 .....	.....	1
Manitoba.....	Alfalfa.....	2	2	.....
	Red Clover...	8	6	2
Quebec.....	Alfalfa.....	3	3	.....
	Red Clover...	1	1	.....
	Alsike.....	1	1	.....
United States	Alfalfa.....	5	3	2
	Red Clover...	4	1	3
	Peas	3	2	1
	Beans	2	1	1
	Soy Beans....	6	1	5
	White Clover.	2	2	.....
	Vetch.....	1 .....	.....	1
New Brunswick.....	Red Clover...	2	1	1

Thus of a total of 120 reports received, 72 showed a benefit to the crop by the application of the bacteria to the seed, as against 48 in which no benefit was apparent.



Fig. 3.—The cultures are sent in glass bottles accompanied by directions for their use.

EXTRACTS FROM REPORTS, 1906.

Big Fork, Ont. Area of plots, each one-eightieth acre. Yield on treated plot, 120 pounds; on untreated plot, 101. Soy Beans.

Manilla, Ont. At the time of harvesting the nurse crop (barley), where the culture was used, the plants were very thick, and the binder cut several inches off the top of the plants. Where the culture was not used, the plants were thin, weak, and of a sickly yellow color. At a distance of half a mile you could easily tell the difference up to the middle of October. Where it was not used, the stubble was not covered at that date, while on the other part of the field there was a thick mat of stems and luxuriant leaves. Alfalfa.

Houghton, Ont. We have had the driest summer we have ever had, and I have more clover where I sowed the treated seed than there is altogether in this neighborhood. I believe the culture helped it grow stronger so it stood the drought. Red Clover.

Thorndale, Ont. The plants on the treated plots are very strong with very numerous nodules, while those on the untreated plot are weakly and dying, and have no nodules. We never have been able to secure a stand of alfalfa before. Alfalfa.

Chesley, Ont. The plants grown from treated seed were much more vigorous than those from untreated seed. The yield was larger, and the beans of better quality. Field Beans.

Dorion, Ont. The treated plants are a beautiful dark green, large and very strong, while the untreated are very small, weakly, and pale in color. Red Clover.

Grimsby, Ont. The crop on the untreated plot was only about half as large as that on the treated plot. Field Beans.

Highland Grove, Ont. In the first part of the season the plants nearly all turned yellow, and I could find no nodules. Then that on which I used the culture turned green, and I have found nodules on them. The plants where the culture was not used seem to have dried off entirely, and that the culture was used on has made a good growth, and has thickened out a lot since I cut the grain with which it was sown. Alfalfa.

Meaford, Ont. The plants on the treated plot made a decidedly better growth. Red Clover.

Rylstone, Ont. The crop on the treated plot looks twenty-five to fifty per cent. better than on the untreated plot. The farm has been rented for fifteen years, and the tenant that had the place before me said he could not raise clover on that field and that I was only throwing away the seed. Now there is no better piece of clover in the neighborhood. Red Clover.

Verner, Ont. The treated plot yielded over six bushels more per acre than the untreated. The treated plants were six inches longer, and stronger than on the untreated plot, with much more numerous nodules. Peas.

Hensall, Ont. Area of plots, one-fortieth acre. Yield on treated plot, four and one-half bushels. Yield on untreated plot, four bushels. Garden peas.

Maplewood, Ont. The amount of crop on the treated plot was easily double the amount of the untreated plot. Beans.

Aurora, Ont. The crop on the treated plot is very heavy, and on the untreated not so rank. The crop on the treated plot is the best catch I have ever had. Red Clover.

Markdale, Ont. Growth on the untreated plot not one-third of that from the treated seed. Vetch.

Morpeth, Ont. The crop on the part treated with culture was five bushels to the acre better than where it was not used. Crop on sandy soil. Beans.

Garry Owen, Ont. Plants on treated plot are more vigorous than those on untreated plot. Clover (Mammoth).

Big Fork, Ont. The treated plot yielded at the rate of four hundred and forty pounds more per acre than the untreated plot. Soy Beans.

Calgary, Alta. Nodules were numerous on treated plot, but absent on the untreated. The crop on the treated plot was so heavy I had the greatest difficulty in binding it. It was a bumper. Peas.

Bon-Accord, Alta. The plants on the untreated plot are not as long by six inches as on the treated plot. The piece on which the culture was used is a long way ahead of the untreated piece. Alfalfa.

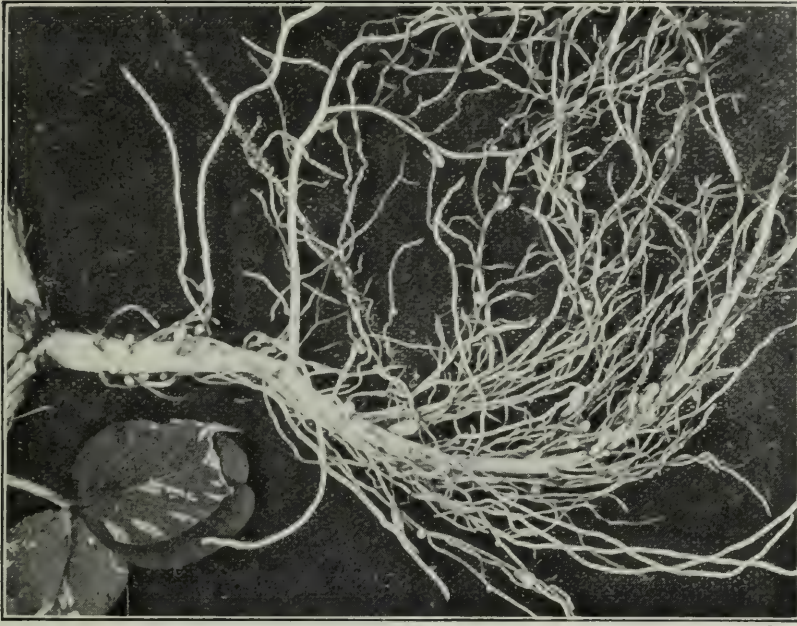


Fig 4.—Root of Red Clover, showing nodules,
natural size.

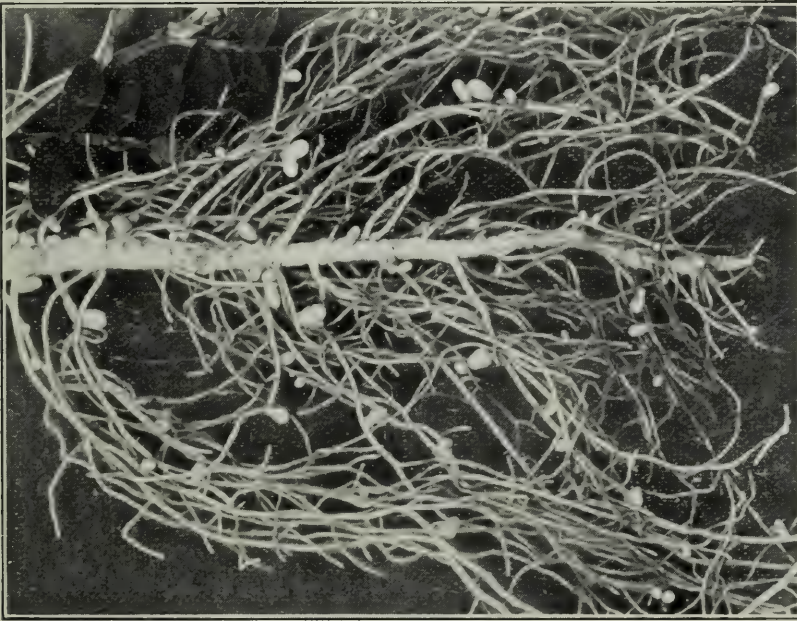


Fig. 5.—Root of Hairy Vetch, showing nodules,
natural size.

Claresholm, Alta. Plants on the treated plot were very dark green in color; those on the untreated plot are pale and not healthy. Alfalfa.

England. The plot sown with untreated seed seemed a good deal affected by the dry weather, while the treated plot seemed to be quite unaffected by the drought. The plants looked a good color and grew stouter than on the untreated plot. Alfalfa.

Moosejaw, Sask. The treated seed bore thick sturdy vines with very dark green leaves; the untreated seed much lighter in color and vine. I did not find a single nodule at any time on the roots of the untreated plot. The treated seed always bore nodules in increasing number as the season advanced, the roots were three or four times as large as the untreated. Peas.

Fleming, Sask. I enclose four samples of clover, two treated with culture and two not treated; one sample of each grown on high ground, and one of each on low ground. (See Figs. 1 and 2.) Red Clover.

Sheffington, P.Q. First cutting yielded two tons per acre on treated plot, one and one-quarter tons per acre on untreated plot. Alfalfa.

Treesbank, Man. Numerous nodules were present on the treated plot, while the untreated plot showed only a few. Alfalfa.

Baldwin, Man. The clover seed treated with the culture showed more vigorous roots and consequently better growth than the seed not so treated. Red Clover.

Idaho Experiment Station, Moscow, Idaho, U.S.A. In pot experiments with white clover, garden pea, garden bean, and red clover, in every case the treated seed developed plants having more numerous nodules than the untreated seed.

Iowa College of Agriculture, Ames, Iowa, U.S.A. In pot experiments with white clover, soy bean, and alfalfa, nodules were present on the plants growing from the treated seed, while those growing from untreated seed showed no nodules.

Langhorne, Pa., U.S.A. The plants on the treated plot are vigorous with numerous nodules, while those on the untreated plot are weak and no nodules are present. Alfalfa.

N. Y. State College of Agriculture, Ithaca, N.Y., U.S.A. Most of our trials with nitro-culture have been failures. The O.A.C. cultures were a success in the one trial we gave them this year. Alfalfa.

Dundee, Mich., U.S.A. The plants on the inoculated plot averaged one-third larger and stronger than those on the uninoculated plot. Peas.

Cultures were sent to nearly every experiment station in the United States. In many cases reports from these stated that the soil seemed to be well inoculated with the nodule-forming bacteria and the culture was of no benefit.

Four cultures were also sent to the Government Farm of Orange River Colony.

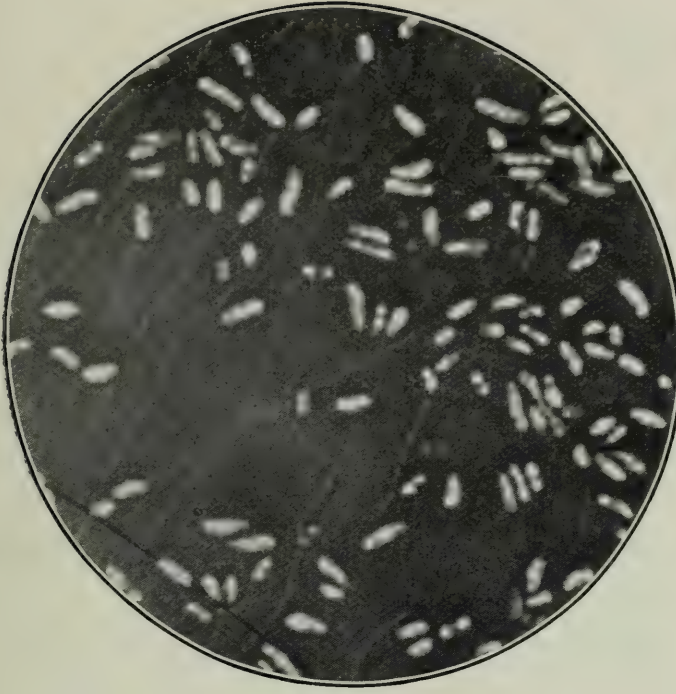


Fig. 6.—Nodule bacteria of Sweet Pea from culture on agar, showing the flagella or whips by which the cells move. Magnified 2,000 diameters.



Fig. 7.—Legume bacteria from nodule on Alfalfa. Magnified 1,500 diameters.

DISTRIBUTION OF CULTURES IN 1907.

During the spring of 1907 the distribution of cultures was continued and reports were received, a summary of which is given in the following table :

Province.	Alfalfa.	Red Clover.	Beans.	Soy Beans.	Alsike.	Peas.	Vetches.
Ontario.....	170	54	5	1	2	29	1
Quebec.....	11	3	2			3	
Nova Scotia.....	3	4	4		2	2	
New Brunswick.....	5	3					
P. E. Island.....	3						
Newfoundland.....	1						
Manitoba.....	1	5				2	
Saskatchewan.....	4	2					
Alberta.....	18						1
British Columbia.....	6	4				2	
United States.....	8	1		1	2		
England.....		5					
Scotland.....		1			1		
Total.....	230	82	11	2	7	38	2

CULTURES SENT OUT FOR THE AGRICULTURAL COLLEGE, TRURO, N.S.

Province.	Alfalfa.	Red Clover.	Beans.	Alsike.	Peas.	Vetches.
Nova Scotia.....	41	38	1	7	12	2
New Brunswick.....	1	5		1		
P. E. Island.....	4	4		2		
Total.....	46	47	1	10	12	2

As during 1906, cultures were prepared in this laboratory for the Truro Agricultural College, reports of such cultures being received by that College.

The total number of cultures sent with the exception of those sent for the Truro Agricultural College, which will not be further considered, was 372. In answer to a request for a report upon the use of the cultures, two hundred and fifty-seven replies were received. In many cases no untreated seed was planted for comparison. Owing to a late, wet spring some farmers did not sow the crop intended; in some cases the entire crop failed by reason of the unfavorable season, etc. Eliminating, then, all reports which did not give actual results as to the success or failure of the cultures to aid the crop, the number available for judging results is 124, the results being shown in the table which follows :

RESULTS OF SEED INOCULATION.

Province.	Alfalfa.		Red Clover.		Alsike Clover.		Peas.		Beans.		Sweet Pea.	
	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.
Ontario.....	36	28	6	11	2	....	2	2	1	....	....	....
New Brunswick.....	2	....	1	....	....	....	....	....	....	....	....	....
Saskatchewan.....	1	2	....	....	....	....	....	....	....	....	....	....
Alberta.....	1	1	....	....	....	....	....	....	....	....	....	....
P. E. Island.....	2	....	....	....	....	....	....	....	....	....	....	....
British Columbia.....	1	2	....	2	....	....	....	....	....	....	1	1
Quebec.....	3	1	....	....	....	....	....	....	....	1	1	....
Manitoba.....	1	1	....	1	....	....	....	1	....	....	....	....
Nova Scotia.....	1	....	2	....	....	1	....	....	2	....	....	....
Indiana, U. S. A.....	....	1	....	....	....	....	....	....	....	....	....	....
England.....	....	....	....	1	....	....	....	....	....	....	....	....
Ohio, U. S. A.....	....	....	....	....	1	....	....	....	....	....	....	....
Total.....	48	36	9	15	3	1	2	3	3	1	2	1

As seen from the table computing the total number of reports available, the number in which benefit was derived from the application of the culture to the seed is to the number in which no benefit was apparent as 67 to 57.

EXTRACTS FROM REPORTS, 1907.

Five Islands, N.S. Numerous nodules on treated seed and few on untreated seed. **Beans.**

Marsville, Ont. Would never sow clover again without using culture. The treated plot made very rapid growth, but there was no catch on the untreated plot. Nodules very numerous on the treated plants. **Red Clover.**

Rocklin, N.S. Treated plants had many nodules and vigorous growth, but few nodules on untreated plot. **Red Clover.**

Eden, Ont. The untreated seed grew fairly well, but the treated seed far surpassed it for thickness and growth. **Red Clover.**

Vankleek Hill, Ont. Treated plants made greater growth, longer and stouter roots, more numerous root fibres than the untreated. **Red Clover.**

McNamee, N.B. Treated plants more vigorous and with numerous nodules. **Red Clover.**

Springhill, N.S. Plants on treated area strong and with many nodules, while those on the untreated plot were tender and few nodules. **Red Clover.**

Bluevale, Ont. Treated plants were very vigorous and of a fine, healthy appearance; untreated plants were not so vigorous and there were some yellow patches. Alfalfa.

Whiteside, Ont. Most unfavorable season for growth of clover in this section for twenty-nine years. Treated seed vigorous, and untreated seed a failure. Alfalfa.

Thamesford, Ont. Marked difference between treated and untreated seed. Three nodules on the treated plants to one on the untreated. A splendid catch and much pleased with it. Alfalfa.



Fig. 8.—Small unbranched form of the nodule-forming organism. From nodule of Lucerne. Magnified 1,000 diameters.

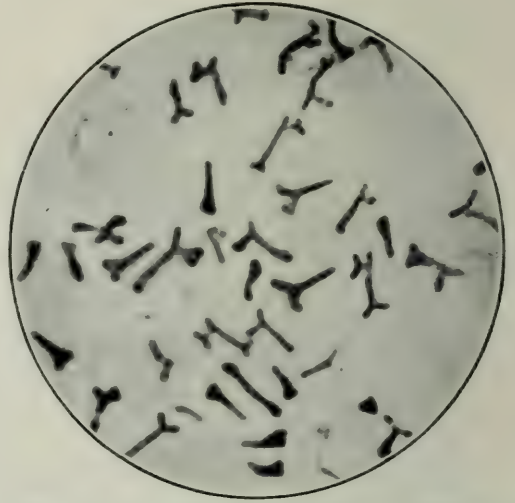


Fig. 9.—Branched form of the nodule-forming organism. From a nodule from Hairy Vetch. Magnified 1,500 diameters.

North Wiltshire, P. E. Island. No nodules on the untreated plants, but very numerous on the treated plants, which are also very strong. Alfalfa.

Caledonia Springs, Ont. No nodules on the untreated plants, but numerous on the treated ones. Treated plants very strong and many roots fourteen inches long. Alfalfa.

Don, Ont. A marked difference between the treated and untreated seed in favor of the former. Treated plants healthy and vigorous. Alfalfa.

Hurondale, Ont. Far better catch with treated seed and stronger plants, although the untreated seed was sown on the best part of the field. Alfalfa.

Clachan, Ont. During the whole season the treated seed showed up the best. Alfalfa.

Jarvis, Ont. Nodules more numerous and plants stronger and greener on the treated seed. Untreated seed turned yellow. Alfalfa.

Lakefield, Ont. Treated plants very strong and of good color. Untreated plants sickly looking. Alfalfa.

Arthur, Ont. Can see division where seed was treated and untreated. Treated plants are more vigorous and of a better color than untreated plants. Alfalfa.

Moir, Ont. Where the culture was applied, the stand is thick and healthy at present, although very small on the untreated part—being thin and sickly looking, much the same as my last year's seeding. Alfalfa.

Charlton, Nipissing, Ont. There was a marked difference in the two plots. The treated seed plants showing a very dark green and hardly any yellow leaves, whereas the others always looked a pale green and are at present about ripening. Several neighbors are taking an interest in this experiment, and it is likely that next spring a few more and bigger applications for culture may be sent from here. Alfalfa.



Fig. 10.—Colony on agar of nodule-bacteria from Garden Bean. Magnified 200 diameters.



Fig. 11.—Colony on agar of nodule-bacteria from Garden Bean. Magnified 100 diameters.

Rawdon, P.Q. Many nodules on the treated seed, but very few on the untreated. Treated plants much more vigorous and longer than untreated. Alfalfa.

Creelman, Sask. Treated plants sturdy and deep rich green in color; untreated not nearly so sturdy nor nearly so deep a green color and later in flowering. Alfalfa.

Raymond, Ont. Numerous nodules and more vigorous plants from the treated than from the untreated seed. Alfalfa.

Loring, Ont. Plants from treated seed vigorous and nodules fairly numerous, none on the untreated seed. Alfalfa.

St. Thomas, Ont. More thrifty and stronger plants from the treated seed than from the untreated. Alfalfa.

SOURCE OF CULTURES DISTRIBUTED.

The cultures which we have sent out to Canadian farmers have been isolated and cultivated in this laboratory, and each culture was from its appropriate host plant. Thus, the alfalfa culture was isolated from a nodule on the root of an alfalfa plant, the vetch culture from the vetch nodule, and so for the red clover, white clover, pea, field bean, etc.

When a pure culture was once obtained it was transplanted at intervals and a record of each transplantation was kept, so that each mother culture, and therefore each culture which we sent out, can be traced back to its original nodule.

The cultures were isolated in the spring and summer of 1904, and had, therefore, been grown on artificial media from two years and a half to nearly three years, and in that time had been transplanted several times. The longest period between two successive transplantations was in some cases more than a year.

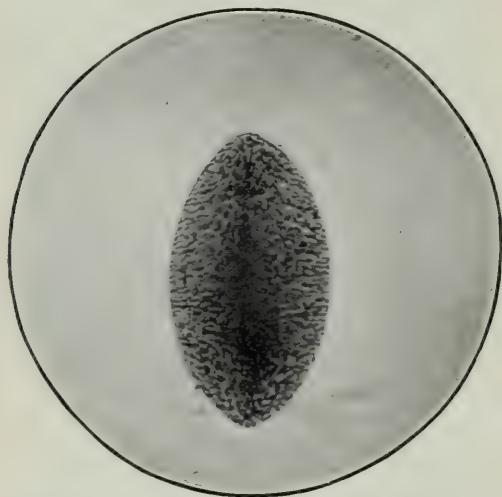


Fig. 12.—Colony on agar of nodule-bacteria from Alfalfa Root. Magnified 200 diameters.

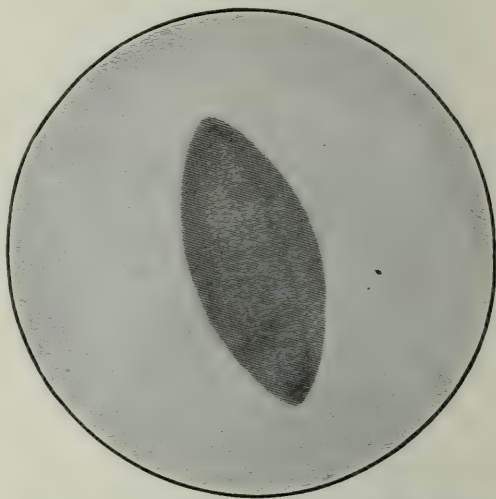


Fig. 13.—Colony of nodule-forming bacteria from Flat Pea. Magnified 100 diameters.

In preparing the culture media, we took pains to exclude combined nitrogen, and the media was all nitrogen poor. Five of the eight cultures were proved, that is, they formed nodules on the roots of their appropriate host plants in the absence of all other bacteria.

During the spring of 1908, cultures of the nodule-forming bacteria will again be distributed from this laboratory to Canadian farmers upon receipt of twenty-five cents for each culture, which is sufficient to treat sixty pounds of seed. It is expected further that the recipients of the cultures will report the results of his experiment, sowing some uninoculated seed for comparison.

Those who intend to use the culture should read what follows:

These bacteria under natural conditions combine the free nitrogen of the air only in association with plants of the bean family. Therefore it

is only a waste of time and material to apply the culture to potatoes, oats, wheat, etc. As plainly stated on each bottle, the cultures are carefully prepared for one species of plant, and if used for other species failure of the experiment may be expected. Plain directions for the use of the culture accompany each bottle, and these directions must be implicitly followed if good results are to be expected.

WHEN INOCULATION IS OF BENEFIT.

If a crop is thriving it indicates that either the soil is plentifully inoculated with the bacteria necessary to produce nodules on that particular species, or else that the soil already contains an abundant supply of nitrogen upon which the plants can live. In either case the use of artificial cultures would be of little if any benefit. On the other hand, if the crop fails to thrive and upon examination no nodules are found on the roots, it is an indication that the culture should be used. Sometimes the use of the culture proves beneficial to the crop when a few nodules are present. Of course, failure to thrive may be due to other causes than lack of nitrogen. The soil may lack available potash or phosphoric acid, or may be deficient in lime. Inoculation does not and cannot remedy this.

When it is intended to sow seed of a legume which never has been grown upon the soil, inoculation of the seed should prove beneficial. This is true even if other legumes have been grown on the same soil, as the bacteria forming root nodules on one species do not necessarily form nodules on the roots of other species.

If soil once becomes thoroughly inoculated as indicated by a successful crop and the presence of numerous nodules, the use of artificial inoculation with later seedings is considered unnecessary if a three-year to five-year rotation is followed.

It should be definitely understood that the use of artificial inoculation with bacterial cultures will in no way compensate for carelessness in selection of seed, preparation of the soil, or subsequent care of the crop.

ADVANTAGES OF SEED INOCULATION.

There are certain advantages over other methods to be gained in the inoculation of seed. Soil may be transplanted from a field which has successfully grown legumes, and used as a top dressing on the field to be sown, but the method, especially if the soil is brought from a distance, is cumbersome and expensive. Furthermore, noxious weed seeds may be carried in such soil, and gain a foothold in sections not previously infested.

When inoculation of the seed is practised, the bacteria remain in intimate association with each seed, and the chances of early root infection and consequent nitrogen assimilation are enhanced. The cultures distributed from this laboratory are for seed inoculation.

The cultures are sent in glass bottles securely packed in a mailing case, each one accompanied by a sheet of directions for its use. (Fig. 3.)

A copy of these directions follows:

DIRECTIONS FOR THE USE OF CULTURES SUPPLIED BY THE BACTERIOLOGICAL
DEPARTMENT OF THE ONTARIO AGRICULTURAL COLLEGE.

This bottle contains bacteria for inoculating.....seed.

The culture is sent you with the understanding that it is to be used for experimental purposes and that you will use it as directed and report to us your success or failure. *Follow directions carefully.*

1. For every sixty pounds of seed to be treated, take one and one-half pints of clean, cool water in a small pail.

2. Pour some of the water into the bottle, shake the bottle thoroughly and pour back the water into the pail. Repeat this six or eight times. The jelly-like substance in the bottle will not dissolve, but may be broken up with a clean stick and stirred in the water.

3. Pour the water from the pail over the seed and mix thoroughly.

4. Spread out the seed to dry in a clean place *out of the sunshine*.

5. The seed will dry in an hour and may be planted in the usual manner as soon as it is dry.

6. Do not add water to the culture in the bottle until you are ready to plant the seed.

7. Some untreated seed should be planted for comparison, and it is well to plant this first.

8. After the seedlings are one month old, search for nodules, "little bunches," on the roots. Examine for nodules again after three months. During the season note number and size of nodules and vigor of plant growth from treated and untreated seed.

REPORT OF NITRO-CULTURE (See Figs. 1 and 2).

Kind used.—Red Clover, Alsike Clover, White Clover.

Character of land.—Loam.

Amount of treated seed.—One hundred and fifty pounds.

Amount of untreated seed.—Four pounds.

	With Nitro-Culture.	Without Nitro-culture.
Area of land planted.....	25 $\frac{1}{4}$ acres.....	$\frac{3}{4}$ acres.
Nodules present or absent.....	Lots of nodules.	None.
Few or numerous nodules.....	Numerous.....	None.
Vigor of plants.....	Good.....	Poor.
Amount of crop.....		

Did you find the culture easy to apply? Yes.

Would you like to continue the experiment? Yes.

Do you consider the use of Nitro-cultures practical? Yes.

Remarks on the weather during the growth of plants : June, very wet ;
July, moderate ; August, September, October, very dry.

Name.—Harry Campbell. *Post-Office.*—Fleming. *Province.*—Sask.

The treated clover is doing splendidly, while the untreated looks spindly and poor. The treated has stood the dry weather far better than the untreated, which has nearly disappeared. I will report the amount next year.

REPORT OF EXPERIMENT WITH NODULE-FORMING BACTERIA FOR LEGUMES.

Crop seeded.—

Character of land.—

Amount of treated seed.—

Amount of untreated seed.—

— — — — —	With culture.	Without culture.
Area of land planted.....		
Nodules present or absent, at one month.....		
Few or numerous nodules after three months . . .		
Vigor of plants after three months.....		

Do you think your crop has been benefitted by the culture?

Remarks on the weather during the growth of plants.

Your Name.

Post Office.

Province.

NOTE.—If desired, write additional notes on the back of this sheet. Please fill out this report and return promptly to *Laboratory of Bacteriology, Ontario Agricultural College, Guelph, Canada.*

APPLICATION FOR NODULE-FORMING BACTERIA.

I desire to conduct an experiment with nodule-forming bacteria for :—
 Alfalfa or Lucerne, Red Clover, Alsike Clover, White Clover, Vetches,
 Peas, Field Beans. (Strike out those not wanted).

Pounds or bushels of seed to be inoculated.

(Each bottle is sufficient for 60 pounds of seed).

Probable date of seeding.

If the culture is sent to me, I will—

1. Carry on the experiment according to the instructions received.
2. Exercise care and accuracy in the work.
3. Report the results of the experiment soon after harvest, whether successful or not.

Name..... Post Office.....

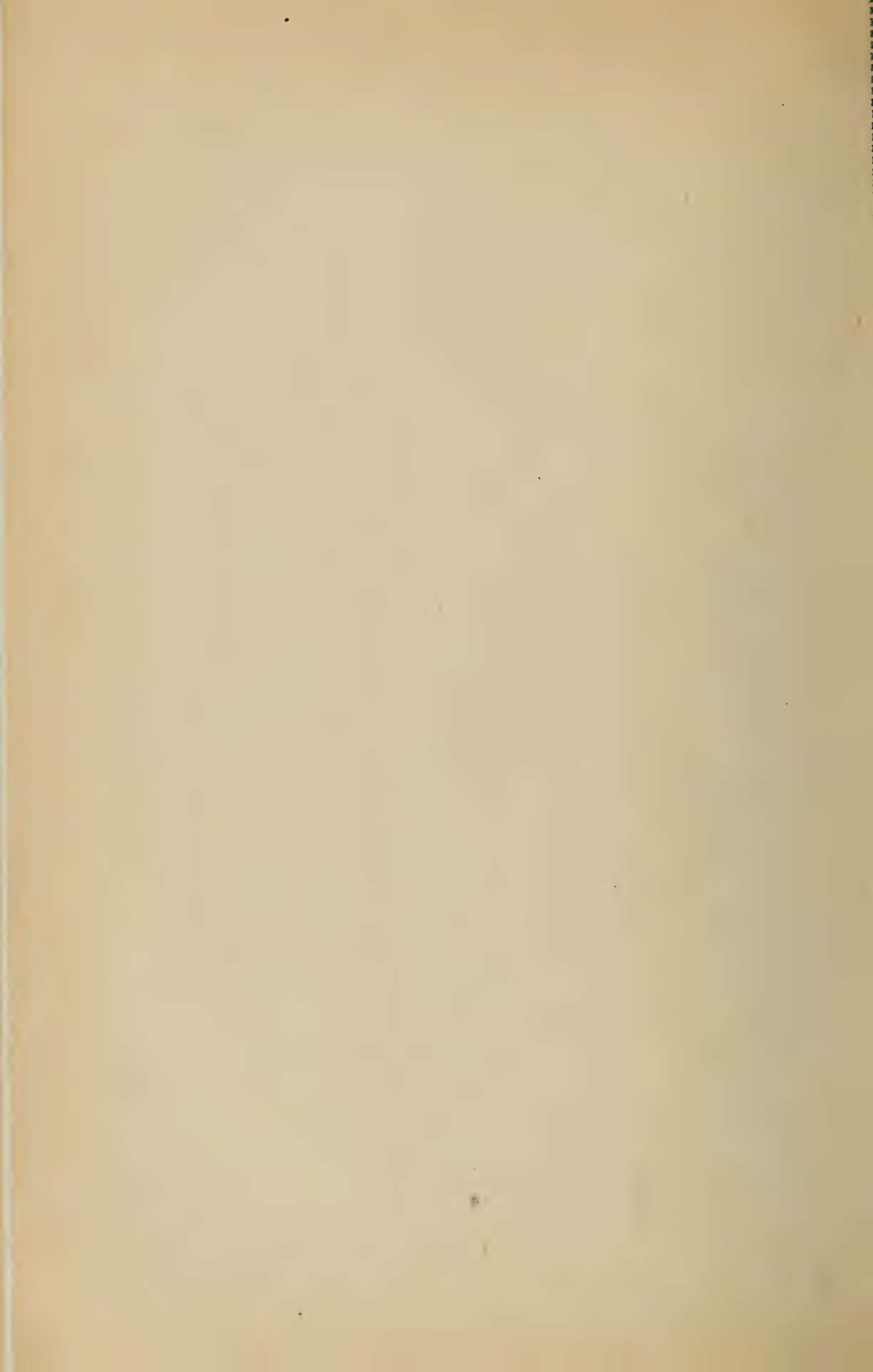
County..... Province.....

Enclosed find..... cents to pay for culture.

This sheet when filled out should be addressed in a sealed envelope to
 the *Bacteriological Laboratory Agricultural College, Guelph, Canada.*

In order to avoid annoying mistakes and delays, write plainly in filling
 out the application.

NOTE—This application form can be detached along the perforated line.



BULLETIN 165.]

[MARCH, 1908.]

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

ALFALFA OR LUCERNE

BY C. A. ZAVITZ, PROFESSOR OF FIELD HUSBANDRY.

Alfalfa, also called Lucerne, is a hardy, perennial, leguminous plant which produces stems of an upright growth, flowers in purple clusters, and roots which penetrate deeply into the ground. It has been grown in the region of the Mediterranean Sea for more than two thousand years, and thrives on soils of various kinds and elevations, and in climates of different degrees of temperature and of different amounts of rainfall. Under favorable conditions, Alfalfa produces an abundant growth of tops which furnishes material of high nutritive value for farm stock. As a feed for farm animals, the crop is used in the form of pasture, green fodder, silage, and hay. When in the best condition for feed it is relished by all kinds of farm stock, including horses, cattle, sheep, swine, and even poultry.

Alfalfa is a great economizer of soil fertility, as it has the power of making use of the free nitrogen of the atmosphere and of the valuable mineral constituents of the subsoil. The abundant growth of roots in an Alfalfa sod has a very beneficial effect in the improvement of both the chemical and the mechanical condition of the soil. It is certainly a valuable crop to raise in those countries in which it will grow satisfactorily.

Experience with the crop shows that Alfalfa can be grown successfully in many parts of Ontario. Not only has it been tested in the Experimental Department of the Ontario Agricultural College, and on small plots over the Province through the medium of the Experimental Union, but it has been successfully grown also as a field crop on many farms in different parts of Ontario for several years past. Apparently, the very best results have been obtained from growing Alfalfa on land which is composed of a fertile soil of good texture, which contains a fair amount of humus and the proper kind of nitrogen-fixing bacteria, and which overlies a subsoil rich in lime and sufficiently open to permit of a full development of the extensive root system of the Alfalfa plants to a considerable depth in the soil. Good results should not be expected from growing Alfalfa on land which has a cold, sour, wet subsoil. It is probably safe to say that the undersoil has a greater influence than the soil at the surface in making the conditions favorable or unfavorable for the successful cultivation of these deep-rooted plants.

EXPERIMENTS IN GROWING ALFALFA AT THE ONTARIO AGRICULTURAL COLLEGE.

A considerable amount of experimental work has been conducted in the growing of Alfalfa in the Department of Field Husbandry at the Ontario Agricultural College. The College farm is located inland about thirty miles from Lake Ontario, sixty miles from Lake Erie, and seventy miles from Lake Huron, and at an elevation of 740 feet above the level of Lake Ontario, and 1,100 feet above the level of the sea. The average rainfall at Guelph is about sixteen inches for the six months from April to September inclusive, and the total precipitation about twenty-seven inches for the entire year. The mean annual temperature is 43.5° F.

The fifty-acre field, in which most of the experiments were conducted, is what might be termed an average clay loam, and has a gentle slope towards the southwest. Part of the land is underdrained with tile, and the remainder has a fairly dry subsoil. The character of the subsoil varies somewhat in different parts of the experimental field from a fairly stiff clay to a combination of clay and gravel. Alfalfa thrives well on all parts of the field, except on the low land, which will not permit of being underdrained to a greater depth than about eighteen inches. On this low land with a wet subsoil the Alfalfa does not usually live for more than two, or possibly for three, seasons.

THIRTY CUTTINGS OF ALFALFA IN TEN YEARS.

The following table gives the yields per acre of the different cuttings of both green fodder and of cured hay of the Alfalfa crop, as produced in the Experimental Department of the Ontario Agricultural College in each of ten years:

Years	Green crop (tons).					Hay (tons).				
	First cutting	Second cutting	Third cutting	Fourth cutting	Total	First cutting	Second cutting	Third cutting	Fourth cutting	Total
1896	9.96	6.47	4.06	2.06	22.55	3.08	1.91	1.29	.65	6.93
1897	12.04	5.61	4.43	.....	22.08	3.59	1.56	1.23	.....	6.38
1898	9.71	5.85	2.64	.....	18.20	2.30	1.75	.63	.....	4.68
1900	11.93	6.00	1.60	.....	19.53	2.33	1.47	.80	.....	4.60
1901	9.70	2.20	7.49	.....	19.39	2.03	1.00	1.50	.....	4.53
1902	13.35	8.69	2.96	.....	25.00	2.50	2.02	.54	.....	5.06
1903	13.10	8.53	2.75	.....	24.38	2.50	2.09	.67	.....	5.25
1904	12.45	9.35	4.00	.....	25.80	3.40	2.50	1.08	.....	6.98
1906	9.78	6.60	4.85	.....	21.23	2.55	1.13	.58	.....	4.26
1907	14.55	3.95	.....	.....	18.50	2.95	1.05	.....	.....	4.00
Aver. 10 yrs.	11.66	6.32	3.48	.21	21.67	2.72	1.65	.83	.07	5.27

The foregoing results were obtained from different seedings which took place in various parts of the experimental grounds, mostly in com-

parative tests with different varieties of clovers. In every case the crop was sown in the spring of the year, at the rate of eighteen or twenty pounds of Alfalfa seed per acre, and usually with a grain crop, such as barley, sown at the rate of one bushel per acre.

In each of eight years, the Alfalfa gave exactly three cuttings, but in 1907 it produced only two, while in 1896 it gave four cuttings in the one season. It will be remembered that the spring of 1896 opened up very early, and that of 1907 exceptionally late. In 1896 the first cutting took place on June 1st and the second cutting on July 2nd, but in 1907 the first crop was not ready to cut until the 2nd of July.

Efforts were made to cut each crop quite soon after it had started to blossom, and always before it was one-third in bloom. The average dates of cutting were as follows: first cutting, June 21st; second cutting, August 2nd; and third cutting, September 21st.

It will be seen that the annual yield of Alfalfa per acre per annum in the average of the ten years' experiments was 21.67 tons of green crop, and 5.27 tons of hay. Hence, green Alfalfa furnishes about 24 per cent., or practically one-quarter, of its own weight in the form of hay. The first gives about double the yield of the second cutting, and the second nearly double the yield of the third cutting. It is generally more difficult to make good hay from the third than from either the first or the second cutting, owing to the unfavorable weather conditions. Within the ten years, here referred to, the Alfalfa produced more than six tons of hay per acre in each of three years, and less than four and one-half tons of hay per acre in each of two years. Since 1888, well-established Alfalfa at the College has been badly winter-killed on only one occasion and partly winter-killed on two occasions. It has usually survived the winter and the early spring in excellent condition. Unfortunately, the results for 1899 and for 1905 were not recorded sufficiently in detail to permit of their being used in the foregoing table.

VARIETIES OF ALFALFA.

There appear to be a few varieties of the wild forms of Alfalfa which are characterized by differences in the color and in the size of the flowers, in the coverings and in the structures of the pods, etc. Botanical authorities, however, have not made it clear that there are marked differences in the botanical structure of the Alfalfa which is used in cultivation. It is, nevertheless, true that the continuous growing of Alfalfa for long periods of time in different countries and under varying conditions of soil and climate, has furnished numerous strains or varieties which vary in important characteristics, when considered from a practical standpoint. Different forms or strains of Alfalfa are known principally by the country in which they have been grown for a number of years. Even this is very indefinite, as for instance, there appear to be different strains of Alfalfa produced in Turkestan, the value of which varies considerably. Much has been claimed in the United States and in Canada for the Turkestan Alfalfa. The results of experiments which have been conducted at Guelph,

however, within the past ten years, show that the so-called Turkestan Alfalfa obtained through the seed trade of the United States and of Canada, has displayed no perceptible advantages over the common variety grown in this Province. Wishing to obtain fuller information regarding the best sources of purchasing Alfalfa seed of the highest quality for use in Ontario, we secured for experimental purposes samples of seed grown in different parts of the world. Some of these were obtained through the kindness and the co-operation of the Department of Agriculture at Washington, and some were obtained direct by the College. In the spring of 1905, twenty-eight plots were sown in duplicate with Alfalfa seed obtained from different sources. From each of the plots three cuttings for hay were made in 1906, and one cutting for hay and one for seed in 1907. The following table gives the average dates of the first appearance of the bloom in the two years, and the total yield per acre of green crop and of hay from the three cuttings in 1906 and the one cutting in 1907:

Source of Seed.	Dates of first bloom. Average 2 years	Total yield per acre. Three cuttings in 1906 and one cutting in 1907.	
		Green crop	Hay
	June	(Tons)	(Tons)
Texas, Panhandle.....	21	28.8	7.3
Turkestan, Khiva.....	22	29.0	7.0
Turkestan, Samarkand.....	22	27.9	6.7
Nebraska.....	18	26.1	6.6
Montana, Northern.....	21	25.1	6.6
Chinese Empire, Sairam.....	21	26.0	6.5
New York.....	17	25.3	6.0
Montana, Southern.....	22	25.0	6.0
Germany.....	18	25.0	6.0
Utah, irrigated.....	22	23.9	5.9
Montana, Northern.....	21	24.5	5.8
Texas, Sherman.....	21	24.4	5.8
Russia, Simbirsk.....	18	26.4	5.7
Kansas.....	25	22.0	5.7
France, Poitou.....	19	25.7	5.6
Colorado.....	21	24.2	5.6
Nebraska.....	24	22.9	5.3
Utah, non-irrigated.....	19	22.0	5.3
United States, First Quality Commercial Seed....	18	22.2	5.0
Ontario, O. A. C. Seed, 1904.....	19	22.4	4.7
Italy.....	19	22.0	4.6
Ontario, O. A. C. Seed, 1903.....	21	20.1	4.3
Russia, Kharkoff.....	18	20.0	4.2
Turkestan, through Wm. Rennie, Seedsman, Toronto.....	23	19.6	4.2
France, Provence.....	21	16.8	3.5
Turkestan, through, Currie Bros., Seedsmen, Milwaukee.....	19	17.8	3.2
Arabia.....	23	.6	.2
Peru.....		.0	.0

It will be observed that the results obtained from the seed of the Turkestan Alfalfa which was obtained in America were decidedly lower than those obtained from the seed of the Turkestan Alfalfa obtained from Turkestan through the Department of Agriculture at Washington.

The plots which were sown in the spring of 1905 from seed produced at the College in 1904 and in 1903 gave quite similar results to the first quality of the commercial seed grown in the United States. It should be stated, however, that both the seasons of 1903 and 1904 were unfavorable in Ontario for the production of Alfalfa seed of average quality. It should also be taken into consideration that the seed produced in 1903 was over a year old when it was sown in the spring of 1905.

It is interesting to observe that the greatest yield of cured hay per acre was produced by seed obtained from the northwestern part of Texas. The yield of the green crop, however, was greater from the seed obtained from Khiva, Turkestan, than from that obtained from any other source.

Although the germination of the seed obtained from Arabia and from Peru was excellent, and the crop in each instance was very promising in the autumn of 1905, the plants of the Peruvian Alfalfa were completely killed, and those of the Arabian Alfalfa were mostly killed before the following summer. Both these strains of Alfalfa are giving particularly good results in the southwestern part of the United States, but owing to their acquired habits of growth prove to be exceptionally tender in Ontario.

In 1907, the second crop of Alfalfa, on each of the plots here referred to, was allowed to go to seed. It was the desire to obtain seed of these different strains in order to continue the experiment, and to ascertain whether or not the seed obtained from the most productive kinds would continue to produce the best results. We hope that in time we shall be able to produce in Ontario a good supply of seed of the very best strains of Alfalfa.

INOCULATION.

It is a well established fact that leguminous crops, such as Alfalfa, Sainfoin, Clover, Peas, Beans, and Vetches, thrive best when they are grown in the presence of a certain species of bacteria. These micro-organisms, when present in the soil, enter the roots of the plants, forming enlargements or nodules on the roots. These very minute forms of life make use of the free nitrogen of the atmosphere, which is thus transferred to the plants, making them decidedly more valuable both in food constituents and in fertilizing materials. Each of the crops here referred to requires bacteria peculiar to itself. It is possible for Alfalfa to grow fairly well without the presence of these minute forms of life, by making use of the nitrogen already in the soil. Their presence, however, seems to have the double value of increasing both the quantity and the quality of the crop. Whether or not the proper bacterial forms are in the soil, can be ascertained by growing a small amount of Alfalfa and examining the roots for the presence or absence of the nodules. If no nodules are

present, it is quite evident that the soil is lacking the proper organisms. These, however, can be brought to the soil either by the application of inoculated soil from other fields, or by the artificial inoculation of the seed. For fuller information regarding this interesting and important phase of Alfalfa-growing, the reader is referred to the report of Prof. S. F. Edwards, as presented in the Ontario Agricultural College Bulletin No. 164.

The first experiments in the inoculation of seeds of leguminous crops were conducted at our College in 1897, when materials containing the nitrogen-fixing bacteria were imported from Germany. At a later date other experiments were conducted with the bacterial preparations obtained from Washington, and still later with those manufactured at our own College. Although we took great care in the experiments, no perceptible advantage in the yield of crop was obtained from the use of the different cultures. This was evidently due to the fact that the soil in the experimental grounds was already well inoculated, which was made quite apparent by the presence of an abundance of tubercles on the plants each year.

SOIL, SEED, AND SEEDING.

For the best results with Alfalfa, not only is it important to select land that is in a good state of fertility to enable the young plants to get a proper start during the first year, and that has a deep, sweet, subsoil with moisture surrounding its particles and with air between them to enable the Alfalfa roots to spread in various directions in search of moisture and of plant food, but it is also important to select land which is comparatively free from seeds and roots of weeds and of other troublesome plants, in order to give the Alfalfa full possession of the soil. We find that the Canadian Blue Grass, in particular, is apt to cause some trouble in growing amongst the Alfalfa plants at the College and in other parts of Ontario, unless the soil is thoroughly prepared before the seed is sown. In all cases, the soil should be well cultivated and a fine seed-bed formed, in order to permit of a quick and a uniform germination of the seed after it has been sown.

The quality of the seed is of vital importance. It should be large, uniform, and bright, of good vitality and free from impurities, especially from seeds of weeds and of other plants which are troublesome in a field of Alfalfa. It is wise to secure a sample before the bulk of the seed is purchased. This can then be examined and if the seeds are large and uniform, are free from seeds of sweet clover, yellow trefoil, etc., and will germinate well when placed between sheets of moist blotting paper or in a box of sand which is kept warm and moist, the larger bulk can then be ordered according to sample. The bulk lot when received should also be examined in order to be sure that it is the same as the sample previously examined. A little care in this way may avoid a total or a partial failure of a crop, and also the introduction on the farm of weeds which are difficult to eradicate.

Experiments have been conducted at the College in sowing Alfalfa in the autumn and in the spring, both with and without a nurse crop. The nurse crop used in the autumn was winter wheat, and that used in the spring was oats. As the result of two distinct experiments, each extending over a period of two years, it was found that the spring sowing gave the best results. The Alfalfa, which was sown in the spring alone, gave an average in the second year of the test of 17.2 tons, and that sown with oats, an average of 16 tons of green crop per acre. The Alfalfa sown in the autumn with winter wheat was partially, and that sown without any nurse crop was very badly winter killed.

In another experiment, spring wheat, barley, and oats were used as nurse crops. Five plots were sown with each kind of grain, thus making fifteen plots sown with grain and Alfalfa seed in the spring of 1899. The average total yields of green Alfalfa per acre obtained from the plots on which the nurse crops had been sown were as follows in each of the years 1900 and 1901:

Nurse Crops.	1900	1901
Spring Wheat	16.3 tons.	24.7 tons.
Barley	13.7 "	22.2 "
Oats	9.5 "	16.3 "

In this experiment the spring wheat proved to be the best, and the oats the poorest crop with which to sow Alfalfa. The oat crop, especially if the seed is sown thickly, has a tendency to smother out the young and tender plants of Alfalfa. All nurse crops used with Alfalfa should be sown quite thinly.

In still another experiment, Alfalfa was sown alone and with one bushel of barley per acre. The test was made in duplicate. The average yield of green Alfalfa per acre during the three following years for each of the plots in both of the sets was as follows:

Sets.	Alfalfa seed sown with	Green Crop.	Hay.
		tons.	tons.
No. 1.....	{ Nurse Crop of Barley.....	20.9	5.4
	{ Nothing.....	20.5	5.3
No. 2.....	{ Nurse Crop of Barley.....	23.6	6.1
	{ Nothing.....	21.3	5.5

This experiment was started in 1895 and finished in 1898. We now sow the Alfalfa seed in the spring of the year and usually with about one bushel of barley per acre. From this system excellent satisfaction has been obtained.

Under ordinary circumstances, we nearly always sow eighteen or twenty pounds of Alfalfa seed per acre, providing it is not sown in combination with different varieties of grasses and clovers. If the crop is to be grown principally for seed production, the amount of seed might be reduced to fifteen or sixteen pounds, and if for pasture or for a cover crop it might be increased to twenty-five or even thirty pounds per acre to advantage.

In preparing the land to receive the Alfalfa seed, it is an excellent plan to cultivate the soil thoroughly, and then to follow with a weeder, or with both a harrow and a weeder, immediately before the seed is sown. If a nurse crop of grain is to be used, the seeder attachment should be placed in front of the tubes of the grain drill. The land should then be levelled either with a light harrow or with a weeder. In this way the Alfalfa seed has the advantage of being located between the rows of grain, and at a suitable depth in well prepared soil which has been worked in such a way as to give the seed the advantage of both the fertility and the moisture in the soil.

INFLUENCE OF MANURES AND FERTILIZERS ON THE ALFALFA CROP.

The influence of manures and of fertilizers depends so much on the mechanical condition and on the fertility of the soil, as well as on so many other conditions, that it makes it a very difficult matter to conduct experiments at any one place and thus obtain results which can be applied to all kinds of land. Some soils are deficient in certain fertilizing elements, and other soils are particularly rich in those very elements; some soils are almost barren of humus, while others contain humus in abundance; some soils are in an acid condition, and Alfalfa would probably receive a decided benefit from an application of lime, while that on other soils would receive no advantage whatever if lime were used. All these things and many others should be taken into consideration when studying the results of fertilizer experiments conducted with Alfalfa at the College and elsewhere, with the object of getting information to use as a guide in other places.

In a representative part of the experimental grounds, four plots, each one-twentieth of an acre in size, were set aside in the spring of 1895 to test the influence of farmyard manure on Alfalfa. On two of the plots farmyard manure was applied at the rate of twenty tons (about twelve loads) per acre, and this was thoroughly mixed throughout the soil. The other plots were left unmanured, and the Alfalfa seed was sown on all four plots. The crops were harvested and the results carefully recorded in each of the three years 1896, 1897 and 1898. The following table gives the average annual yields of green crop and of hay per acre of the duplicate tests conducted during the three-year period:

Condition of soil.	Green Crop. (tons)	Hay. (tons)
Manured land.....	22.4	5.8
Unmanured land.....	20.7	5.3

These results show an annual difference of about one and three-quarters tons of green crop, or of one-half ton of Alfalfa hay per acre in favour of the land which had received the farmyard manure, at the rate of about twelve loads per acre before the Alfalfa seed was sown.

In another experiment, farmyard manure at the rate of twenty tons and hen manure at the rate of five tons per acre were applied as top dressings on Alfalfa plots which had already produced seven cuttings of Alfalfa. The manures were applied after the first cutting of Alfalfa had been taken from the land in 1902. After the application of the manures was made, two crops in 1902 and three crops in each of the years 1903 and 1904 were harvested, and the results recorded. The yields of green Alfalfa in tons per acre as follows :

	1902	1903	1904
1. Farmyard Manure.....	12.8	22.0	26.2
2. Hen Manure.....	13.2	19.8	23.8
3. No Manure.....	11.7	19.3	23.7

The first crop in 1902, before the manures were applied, produced green Alfalfa on the plots of the duplicate test at the following rates per acre : No. 1, 12.1 tons ; No. 2, 12 tons, and No. 3, 12.7 tons. The influence of the hen manure was quite marked at first, but that of the farmyard manure was more lasting.

Two experiments with commercial fertilizers on Alfalfa have been conducted at the College. One of these, consisting of twenty plots, was started in 1899, when the fertilizers were used in the same spring in which the Alfalfa seed was sown, and the other, consisting of twelve plots, was started in 1902, when the fertilizers were used on Alfalfa sod which was well established. The first experiment consisted of four tests with five plots in each, and the second experiment of two tests with six plots in each test. The fertilizers used in each test consisted of muriate of potash and nitrate of soda, each sown at the rate of 160 pounds ; of superphosphate, at the rate of 320 pounds ; and of complete fertilizer, at the rate of 213 pounds per acre. In each test in the second experiment Thomas' phosphate powder was also used at the rate of 320 pounds per acre. One plot was left unfertilized in each of the tests of both experiments. After the fertilizers were applied, the first experiment was con-

ducted for two and the second for three years. The results of these experiments show that the phosphatic fertilizers gave the greatest yield of Alfalfa per acre. Of the different fertilizers used, the superphosphate gave the highest yield per acre in the first experiment, and the Thomas' phosphate powder the highest and the superphosphate the second highest in the other experiment. The greatest average annual yield of green Alfalfa per acre was produced on the land which had received the superphosphate at the time the seed was sown, but this increase, over the crop produced on the unfertilized land, was only one-half of a ton per acre.

USES OF ALFALFA.

Alfalfa can be used in Ontario for the production of hay, green fodder, pasture, seed, green manure, silage, a cover crop in orchards, etc. It is quite probable that its use in this Province will be in about the order in which the list is here given.

For the production of hay it is a most valuable crop. Under favorable conditions it produces large yields of hay of excellent quality. Very great care, however, should be taken to cut the Alfalfa just as it is starting to come into blossom, and always before it is more than one-third in bloom, as the crop very rapidly depreciates in digestibility after it has reached the stage of maturity referred to above. Great care should also be taken to not allow the Alfalfa to lie very long in the hot, dry sunshine, as the leaves soon become crisp and are easily broken from the plants. As the leaves are the richest part of the Alfalfa, special care should be exerted to have as few as possible lost. After the crop becomes sufficiently wilted it should be raked into winrows, and the curing process should be finished in the winrows or in the cocks.

The green fodder produced by Alfalfa is both nourishing and appetizing. It is often an advantage to start to cut Alfalfa for green fodder some time before it has started to bloom. The portion of the crop which cannot be used for this purpose before one-third of the blossoms have made their appearance should be cut and cured into hay. The fact that Alfalfa is a perennial plant, as well as the fact that it produces two, three or four cuttings in the one season, makes it a very desirable crop to use for the production of green fodder for feeding to farm stock.

In the average results of experiments conducted at the College in four different years, Alfalfa, when grown alone, gave a greater yield of pasture per acre than any one of the following crops: Common Red Clover, Mammoth Clover, Alsike Clover, White Clover, Yellow Trefoil, Sainfoin, or Burnet. When grown and pastured alone, however, there seems to be even a little greater risk of cattle and sheep becoming bloated when pasturing on Alfalfa than when pasturing on clover. There is also a danger of either cattle or sheep eating the Alfalfa so closely to the ground that they are apt to injure the crowns of the roots, and in some cases entirely kill the plants. Some very excellent results have been obtained from pasturing hogs and poultry on Alfalfa.

The writer has never heard of injurious results from bloating with any kind of farm stock pasturing on Alfalfa, providing it is used in combination with grasses and clovers in the form of a permanent pasture.

In each of five or six years, seed has been produced at the College from either the first or the second cuttings of Alfalfa. The results have been about the same from each cutting. The production of seed has been only fairly satisfactory at the College, but in some parts of Ontario Alfalfa seed growing is becoming an important industry.

No extensive experimental work has been conducted at the College in the production of Alfalfa silage, but a few reports have been received, stating that the crop can be used in that way with fair satisfaction.

Alfalfa certainly produces a large amount of exceedingly valuable material to use as a green manure. In the majority of cases, however, it is probably better to use the crop for feeding purposes, and then to save the manure and return it to the land in that form rather than to plow under the whole crop.

It is quite probable that there are many crops more suitable for using as a cover crop in orchards than Alfalfa. The growth of the plants is upright and rather open, and the roots penetrate so deeply into the soil that they tend to rob the subsoil of its fertility and of its moisture, both of which are so essential to the best welfare of the trees.

QUALITY OF ALFALFA AS A FEED.

In the years 1897 and 1898 Alfalfa was grown in our Experimental Department, and in comparison with red clover and with timothy both the chemical composition and the digestibility of the crops were determined in the Chemical Department of the College. The results of these investigations were given in detail in the Ontario Agricultural College Bulletin 111, which was issued in the year 1900. The following table gives the comparative amounts of digestible constituents in one ton of hay of each of the three crops :

Constituents.	Alfalfa. (lbs.)	Red Clover. (lbs.)	Timothy. (lbs.)
Protein.....	192.2	141.0	48.7
Fat.....	30.0	29.4	16.2
Nitrogen Free Extract....	496.6	587.4	528.4
Fibre.....	205.5	209.4	306.9

The figures here presented are quite suggestive and are worthy of careful study.

In "Farmers' Bulletin Number 215," issued by the Department of Agriculture of the United States in 1905, we find in the investigations there quoted the digestible protein to be 10.44 per cent. for Alfalfa hay and 6.8 per cent. for red clover hay. These figures would be equal to

208.8 pounds per ton of the former and 126 pounds per ton for the latter.

These investigations show Alfalfa hay to contain about fifty per cent. more digestible protein than hay made from common red clover. It is certainly true that well cured Alfalfa hay is exceedingly nutritious.

INFLUENCE OF ALFALFA ROOTS ON THE SOIL.

In the years 1900, 1902 and 1903 experiments were conducted to ascertain the comparative value of the sods of Alfalfa and of Timothy. After the crops were removed from the plots the land containing the roots of these crops was plowed. On the sods of 1900 winter wheat was sown in the autumn of the same year; on those of 1901, barley was sown in the spring of 1902, and on those of 1902 corn was planted in the spring of 1903. The average yields of the crops produced per acre are shown in the following table:

Sod.	1900 Winter Wheat.	1902 Barley	1903 Corn
	Bushels.	Bushels.	Tons.
Alfalfa Sod.....	61.5	30.2	24.0
Timothy Sod.....	42.1	19.7	17.9

In 1902, the test with Alfalfa and with timothy sods was repeated four times. Barley was sown on each of the eight plots in the spring of the year. The detailed results of yields per acre are very interesting, and are as follows:

Tests.	Alfalfa Sod.	Timothy Sod.
	(bus.)	(bus.)
Number 1.....	27.9	13.4
" 2.....	31.7	20.1
" 3.....	31.0	19.6
" 4.....	30.3	25.7

In comparing the mechanical condition of the soil on which Alfalfa and different varieties of clovers and of grasses had been grown, it was found that there was a marked difference resulting from the action of the roots of the different crops on the soil. This influence was shown in two ways in particular: first, by the difficulty or the ease in plowing the land, and second, by the stiffness or the mellowness of the upturned sods. In the spring of 1902, twenty-eight plots of sod were plowed. These were made up of four separate tests, each consisting of seven plots. Each test contained the sods of one variety of Alfalfa, and three varieties each of clover and of grass. When the plots of each of the four tests were

plowed, careful examinations were made and detailed notes were taken regarding the physical condition of the soil in each instance. It was found that the Alfalfa sod was more difficult to plow than that of any of the clovers or the grasses, but that the inverted sod of the Alfalfa plots was exceedingly mellow and friable, surpassing all others in this particular. The comparative differences of the various sods can be understood fairly well from the following figures :

Sods.	Difficulty or ease in plowing, 10 being most difficult.	Loose, friable condition of inverted sod, 10 being most friable.
Alfalfa.....	10	10
Common Red Clover.....	5	7
Mammoth Clover.....	6	6
Alsike Clover.....	4	8
Timothy.....	8	3
Meadow Fescue.....	7	4
Orchard Grass.....	7	4

An Alfalfa sod is usually a little more difficult to plow than that of some of the clovers and the grasses, owing to the very large roots of the Alfalfa plants, which are frequently pulled out of the subsoil instead of being broken or cut in two. When the roots, to the length of two, three, four or five feet or even more, are pulled out of the subsoil and left in the surface soil, a large amount of root material is thus deposited in the land at the very surface. The land is thus left in excellent physical condition, and as the roots decay they supply a large amount of humus, rich in fertilizing elements. In 1898, the Experimental Department spent some time in removing the Alfalfa roots from the land to a depth of two feet. This was divided into four layers, and the roots were carefully separated from each layer. The roots from each of these depths were then taken to the Chemical Department, where they were analyzed. The percentages of the fertilizing constituents in the dried roots of seventeen months' old Alfalfa were as follows for each of four depths in the soil of six inches each :

Roots taken from different depths of soil.	Nitrogen N.	Potash K ₂ O.	Phosphoric Acid P ₂ O ₅ .	Lime Ca O.
First six inches.....	1.64	.66	.55	.59
Second six inches.....	1.58	.41	.55	.38
Third six inches.....	1.59	.43	.51	.48
Fourth six inches... ..	1.58	.42	.48	.75

The roots of young Alfalfa plants were found to contain larger percentages of fertilizing materials than those of the plants which were

seventeen months old. For the details of the results of the composition of Alfalfa roots from which these figures have been quoted, the reader is referred to pages 20 and 21 of the Annual Report of our College for 1908.

ALFALFA GROWN IN COMBINATION WITH GRASSES AND CLOVERS.

Five distinct tests have been made at the College in comparing twenty-one different mixtures of grasses and clovers for hay production. One test was started in 1897, one in 1898, two in 1900, and one in 1906. Each of these tests have been completed with the exception of the last one mentioned, which will be finished in 1908. Crops of green fodder and of hay were obtained from the four tests in each of two years. Alfalfa was included in seven of the mixtures. Of the twenty-one different combinations the six highest yielders of hay contained Alfalfa—the greatest yield being produced by the mixture of Alfalfa and tall oat grass. The details of the entire experiment will not be presented until after the results of 1908 have been secured. The following table, however, gives the average annual yield in tons of green fodder and of hay per acre of four of the mixtures in the four tests already completed:—

Mixtures.	Green Fodder.	Hay.
Alfalfa and Tall Oat Grass.....	15.17	4.41
Alfalfa and Timothy.....	13.80	4.00
Common Red Clover and Tall Oat Grass.....	10.71	3.39
Common Red Clover and Timothy.....	10.99	3.20

Although Alfalfa and tall oat grass gave an average annual yield of 1.2 tons of hay per acre more than common red clover and timothy, it is doubtful if even this mixture will equal Alfalfa alone for hay production.

Permanent pastures have never occupied as prominent a place in the agriculture of Ontario as they have in the agriculture of Great Britain. The scarcity of labor and the great development of our live stock industry are factors which are causing some of our most thoughtful farmers to consider the advisability of securing a first-class permanent pasture instead of relying so much on timothy for pasture purposes. Fields which are located long distances from the farm buildings or which are difficult to work on account of the presence of steep hill-sides, crooked rivulets, low spots, etc., might be converted into permanent pastures and thus prove of great economic value. This arrangement would not interfere materially with the regular crop rotation of the farm. From more than twenty years' work in testing different varieties of grasses and clovers, both singly and in combination, I would suggest the following mixture for permanent pasture on an average soil in Ontario: Alfalfa, 5 lbs.;

alsike clover, 2 lbs. ; white clover, 2 lbs. ; meadow fescue, 4 lbs. ; orchard grass, 4 lbs. ; tall oat grass, 3 lbs. ; meadow foxtail, 2 lbs. ; and timothy, 2 lbs. ; thus making a total of 24 pounds of seed per acre. These varieties are all very hardy. Some of those used in Great Britain are not permanent in this country. None of the smaller growing varieties, such as the blue grasses and the bent grasses are mentioned, as there is scarcely a farm in Ontario in which the Canadian blue grass, the Kentucky blue grass or the red top will not grow naturally. The varieties here recommended are strong vigorous growers. Some of them produce pasture very early in the spring and others later in the season. Most of the varieties are superior to timothy in producing a growth during the hot, dry weather which occasionally occurs in the months of July and August. The seed can be sown in the early spring either alone or with a light seeding of spring wheat or of barley. Such a mixture as this when well established on suitable land should furnish a pasture, abundant in growth, excellent in quality, and permanent in character.

CONCLUSION.

Alfalfa should be very carefully tested on many farms throughout Ontario. Its large yields of nutritious feed for farm stock, its perennial character of growth, and its beneficial influence on the soil, are all features which commend it very highly for those farms on which it can be grown successfully.

There are different ways of laying down a plot or a field to Alfalfa, and we would suggest the following method as one which is likely to give very excellent results. Select land having a clean, mellow, fertile surface soil overlying a deeply drained subsoil having no acidity. Use large, plump seed, free from impurities and strong in germinating power. Inoculate the seed with the proper kind of bacteria, providing Alfalfa has not been grown successfully on the land in recent years. As early in the spring as the land is dry enough and warm enough to be worked to good advantage, make a suitable seed-bed and immediately sow about twenty pounds of Alfalfa seed per acre from the grass seed box placed in front of the grain drill, and about one bushel of spring wheat or of barley per acre from the tubes of the drill. Smooth the land with a light harrow or with a weeder, and if it is very loose and rather dry, also roll it and again go over it with the harrow or the weeder. As soon as ripe, cut the grain and avoid leaving it on the land longer than necessary. Give the Alfalfa plants every opportunity to get a good start in the autumn in preparation for the winter. If for hay, cut each crop of Alfalfa in the following year as soon as it starts to bloom. In curing, try to retain as many of the leaves on the stems as possible, and to protect the crop from rain. Never cut or pasture Alfalfa sufficiently close to the ground to remove the crowns of the roots, and thus injure or possibly kill the plants. If these directions are followed, the Alfalfa may be expected to produce large and valuable crops for a number of years without re-seeding.

Ontario Department of Agriculture.

HORTICULTURAL BRANCH.

BEE-KEEPING IN ONTARIO.

The information contained in this report has been taken from answers to questions sent out in a circular to all the bee-keepers of the Province, dated May 15th, 1908. While the Province has been fairly well covered by the reports received, there were over 1,500 bee-keepers who did not return the blanks sent to them. Until a greater proportion of those engaged in the industry take enough interest to answer the few questions asked, it will be impossible for the Department of Agriculture to prepare as full and accurate a report as is desired.

Of the reports received, only 10 per cent. answered that the industry was carried on at all extensively, and this percentage is perhaps high, as in some cases, more than one individual so reported in the same vicinity. Others noted that while the business was once in a flourishing condition, the losses of the past two years had made a material change, and that now few large apiaries were left, while the smaller ones were in many cases wiped out of existence. The census report of 1901 gave the Province a total of 116,403 colonies, but from the information at hand, this total for the present year must be decreased at least 33 per cent. to cover the heavy loss of 1907 and 1908. These changes will doubtless tend to keep up prices for the better quality of honey, and those who have any bees left should give them special attention, as the natural increase and the surplus honey gathered will both prove sources of profit at the present time.

Very little disease was reported. While the percentage of dysentery seems high, in every case the correspondent stated that the attack was slight, generally occurring in only one or two hives in an apiary. Of the instances where foul brood was reported, in only two cases was the attack a severe one. European Foul Brood has appeared in the vicinity of Trenton in rather a virulent form, and has caused heavy losses in two apiaries.

The work of the six Inspectors appointed last year has shown itself favorably in the reports received, and the decrease in the disease has been evident. This year, the Province has been divided somewhat differently and the Inspectors' names with their districts are as follows:—

W. A. Chrysler, Chatham: Counties of Essex, Kent and Lambton.

John Newton, Thamesford: Counties of Elgin and Middlesex.

D. Chalmers, Poole: Counties of Perth and Huron.

Jas. Armstrong, Cheapside: Counties of Norfolk, Oxford, Waterloo and Wellington.

Wm. McEvoy, Woodburn: Counties of Haldimand, Welland, Brant, Lincoln, Wentworth and Halton.

H. G. Sibbald, Claude: Counties of Bruce, Grey, Simcoe, Dufferin, Peel and Muskoka.

J. L. Byer, Mt. Joy: Counties of York, Ontario, Victoria and Durham.

From Northumberland east to the boundaries of the Province, a special Inspector will be sent out to look over the apiaries at every important point. At the present time outside of the outbreak of European Foul Brood at Trenton, the Department has no definite information in respect to the prevalence of foul brood or otherwise in most of this territory, and it has been thought advisable to select a man from elsewhere in the Province who is thoroughly conversant with the disease in all its stages to make a careful investigation in the east. All suspected apiaries will first be visited, and any bee-keepers wishing to clear up any doubt as to the presence of this disease in their apiaries should send word to the Department of Agriculture at an early date.

Apiarists in other districts should report all cases of suspected foul brood either direct to the Inspector for their district or to the Department of Agriculture, Parliament Buildings, Toronto.

Reports were received from every county in the Province, but those counties where bee-keepers' associations have been organized sent in by far the largest number of answers. Evidently these associations have proved of much assistance and encouragement to those engaged in the industry, this being shown in the greater number of reports received and the care taken in answering the questions submitted.

The following data have been taken from the information received:

	Colonies.			
	100 to 400.	50 to 100.	25 to 50.	Under 25.
Average loss in Winter.....	17	19	16	24
Wintered in cellar.....	67	53	46	44
Wintered outdoors, protected.....	33	44	46	50
Wintered outdoors, unprotected		3	8	6
Disease reported :—				
Foul brood	5	7	7	1
Dysentery	45	33	32	17

The reports as a whole indicate that the bees wintered well, but suffered later in many localities from the cold spring. The terrible losses of the previous winter are again emphasized, and it will take years to build up to the number of colonies then scattered over the country. While among the larger bee-keepers, the losses were bad enough, the smaller

apiaries will feel the loss most, as in the majority of cases almost every colony was wiped out. A great deal has been heard of the disastrous effects of foul brood and of the ravages attending this disease, but these have been trifling compared with the total losses of the past few seasons from other causes.

Much of the loss has been due to neglect and carelessness. The larger bee-keepers have specialized in this industry, and, being dependent upon it alone for their livelihood, have studied the requirements of their stock and have given their colonies the best attention. Many others have engaged in bee-keeping as a side line, and left the bees largely to themselves, except perhaps at the time of honey flow when they have taken off whatever surplus was available. Others, again, have kept from one to five colonies to produce enough honey for home use only, and these also have suffered for lack of proper attention, as their owners are generally too busy at the proper season with other farm labor to bother with them.

Yet, to the farmer who will make a business of keeping and looking after from 10 to 25 or 50 colonies, a splendid profit may be made on the necessary investment. Like every other business, care and knowledge is required, and most of the latter can be gained only by experience. Small beginnings should be made and the natural increase under favorable conditions will soon give the number of colonies required. It must be understood that the profits are as great as from any other part of the farm, provided the same care is exercised in looking after the bees as is usually given to other stock or to the orchard. In addition to the crop of honey harvested, the bees are valuable adjuncts to the proper fertilization of blossoms in the orchard and in the alsike clover fields. They take nothing from the soil or other parts of the farm yet give handsome returns for their keep.

In many parts of the Province are districts now unoccupied by bee-keepers, where larger apiaries could be kept with profit. Alsike, white clover, buckwheat, basswood and other honey producing crops are grown more or less everywhere, while in certain sections these occur in such abundance as to furnish large surpluses of honey in favorable seasons. By means of out-apiaries, from 200 to 300 colonies or over may be run in these places with good results by a person giving his time to this work.

Honey-producing crops have stood the winter well, and are growing luxuriantly. The cool, wet spring, and subsequent hot weather, have brought forth rapid growth and all prospects indicate an abundance of clover bloom. Many fields intended for spring grains, but untouched owing to the wet land, will be planted to buckwheat, ensuring a good harvest of this honey later in the season. Altogether the outlook is very promising for a good yield of all kinds of honey to those who have by care and skill carried their bees through the past two unfavorable springs.

Owing to the tremendous losses during 1907, the total crop will be much reduced even if every colony should harvest a good average of both clover and buckwheat. This shortage combined with the rapidly increasing markets in the west will undoubtedly tend to keep up the prices to

about what they were during the past season. This applies specially to the better grades, as the poorer grades are now being imported in large quantities, and can be laid down in Ontario at a very low price. As many of the careless bee-keepers have been cleaned out by disease and the cold springs, the quantity of the poorer grades will fortunately decrease. This should result in a better quality on the market and in increased consumption. Very little adulteration is being practised, and the reports of the Inland Revenue Department, Ottawa, have served to call attention to the excellent quality of our Ontario honey.

The following reports are taken from among some hundreds received and are from apiarists having 100 colonies and over :

Brant : General condition somewhat weaker in brood and bees than in the average season, but building up fast. Loss 5 per cent., due to queenlessness; wintered in cellar, put in November 20 and taken out March 25; fed sugar syrup in fall about 20 lbs. to each colony; honey crops in good condition, alsike not much grown, but good growth of white clover.

Bruce : General condition fair to good, loss during winter about 8 per cent., chiefly from failing queens; a few cases of dysentery; wintered in cellar, put in November 25, removed April 22; sugar syrup fed to make up any shortage; clovers came through in fair condition, but not much alsike grown for seed near this apiary.

Dufferin : Colonies generally weak, nearly half of brood dead, in some cases seemingly chilled brood; considerable dysentery present; bees wintered in cellar; put in November 18th, removed April 22nd; buckwheat honey fed for winter stores; alsike not cultivated to any extent; white clover wintered safely.

Dundas : Quite a number of colonies came out weak, but these are improving rapidly on good pasture and weather; loss heavy, 33 per cent., partly in cellar and remainder after being placed on summer stands; last year being such a poor honey year, quality of honey had a great deal to do with losses, some of honey having soured; wintered in cellar, put in November 18-20th, removed in April; enough surplus honey stored so did not need to feed sugar syrup; clover wintered well in this vicinity and is generally very abundant; basswood has been good source of nectar but is getting thinned out very rapidly.

Durham : General condition good; wintered in summer stands in double walled hives; loss of three colonies, queenless; crops wintered fairly well and include white clover, alsike, basswood, shumac, golden rod and buckwheat.

Elgin : Judging from my own, bees seem to have wintered well outside; neighbor wintered his in cellar and bees are in poor shape; loss 8 per cent., part queenless and balance through not being cared for soon enough in out yard; bees wintered outside, packed four in box in leaves, put in October 31st, out May 20-25th; honey for winter stores; clover came through well and prospects look good for a crop, alsike grown to large extent and white clover common, basswood pretty well cut out.

Essex : Bees came out of winter quarters in splendid shape ; loss only 5 per cent., these being queenless ; wintered on summer stands mostly in clamps, put in last week October, removed last week of May ; honey fed for winter stores ; white clover and alsike never in better condition ; I work for both comb and extracted honey.

Frontenac : General condition extra good, loss 12 per cent., wintered in cave in sand hill, outdoors, put in November 1-5, removed April 15th ; honey and sugar syrup fed to late made colonies for winter stores ; little disease except dysentery in four hives ; white clover came out fine, alsike little grown in this section.

Glengarry : Those who wintered their bees with combs from top story wintered well, others that fed sugar late did poorly ; own loss 20 per cent. ; too warm in cellar ; bees put in November 10th, removed April 15th ; all colonies finished with from 10-25 lbs. sugar for winter ; considerable dysentery present ; clovers wintered well and are principal honey plants.

Grenville : General condition fair to good ; mostly wintered in cellars ; honey fed for winter stores ; quite a lot of dysentery present ; clovers came through in excellent condition ; other honey producing plants are, basswood, buckwheat, wild cherry, raspberry, golden rod, boneset, etc.

Grey : Bees came out weak, but doing well since ; loss 20 per cent., due to starvation and spring dwindling ; wintered part in cellar and balance outside packed ; honey fed for winter stores ; clover came through well and is main honey plant here.

Haldimand : General condition good ; no loss, wintered outdoors packed in chaff and sawdust in November ; part honey and part sugar syrup fed for winter stores ; clovers came through fine, a lot being grown here.

Halton : Colonies in good condition ; loss about 7 per cent., due to old queens and queenlessness ; wintered two-thirds in cellar, balance in separate hives, packed with sawdust on summer stands ; put in November 20th, out April 14th ; winter stores, sugar syrup ; clovers wintered well ; alsike, white clover and basswood being the only plants to give any surplus ; alsike grown more largely this season.

Hastings : General condition only medium, spring has been cold and wet ; loss 14 per cent., due largely to flooding of cellar, causing dysentery ; put in cellar November 29th, removed April 22nd ; honey fed for stores ; white clover rather good shape ; alsike poorer, we depend on clovers and buckwheat for our crop.

Huron : General condition fair to poor ; some wintered well, others had considerable loss through cold and queenlessness, wintered outdoors in clamps, honey with a little sugar syrup fed for winter stores ; clovers came through fine ; alsike and white clovers being grown extensively.

Lambton : General condition good with few losses, only 4 per cent., in own apiary ; wintered in clamps packed in dry sawdust, put in November 1st, removed May 1st ; no disease present ; clovers came through winter all right ; raspberries and basswood also give surplus honey.

Lanark : Colonies in poor condition, heavy losses general; 40 per cent. in this apiary, due largely to starvation; no honey gathered after July of 1907; wintered in cellar, put in November 10th, removed April 17th; clover wintered well, but not much alsike grown; very large crop of dandelions in spring.

Leeds : Colonies in fairly good condition notwithstanding continuance of cloudy and rainy weather; loss 9 per cent.; bees wintered in cellar, put in November 8th, removed April 20th; sugar syrup largely fed for stores in this vicinity; some few colonies showed presence of dysentery; white and alsike clovers suffered badly from drought of 1907, but the rains of this spring have brought the clover into nice condition.

Lincoln : General condition good; no loss whatever; bees wintered partly in cellar, and partly outdoors packed in cases; stored November 28th, out again March 25th; sugar fed to make up what bees lacked in natural stores; no disease present except a little dysentery; crops wintered very well, these with a little basswood being only sources we have here for surplus honey.

Manitoulin : General condition poor; loss 33 per cent. from dampness in cellar and lack of queens; bees were put in November 15th, taken out May 5th; clovers came through winter in very poor condition.

Middlesex : Some loss reported among small bee-keepers; none in our apiary, and bees are in grand condition; colonies wintered on summer stands packed in clamps, four in each clamp; put away first part of October, and unpacked on 18th of May; bees were fed on sugar syrup, which is the best stores one year with another, no signs of disease present; we are very well supplied with both wheat and alsike clover, both at home and out-yard; these crops never looked better.

Muskoka : General condition very good, but loss about 20 per cent.; were re-queened heavily last fall and some were queenless this spring, this being particular cause of loss; bees wintered in clamps on summer stands packed in four inches forest leaves with some fine sawdust; bees were placed in clamps about October 1st and removed May 20th; sugar syrup fed for winter stores; clovers in good shape and grown to quite a large extent.

Norfolk : Bees came out in fair condition; loss 4 per cent., due to experimenting in swarming; bees wintered in basement of stock barn partitioned off by themselves; bees housed December 30th, set out April 7th; no winter stores necessary as the colonies averaged 30 lbs. honey each when put in; all clovers came through winter in good shape; this is a white clover locality but farmers have just nicely started in alsike.

Northumberland : Colonies strong; loss 9 per cent., caused by old queens, and in some cases by spring dwindling; bees wintered in cellar put in December 1st, taken out April 5th; each colony fed 10 lbs. of sugar syrup for winter stores; clovers wintered well and are grown to quite an extent.

Ontario : General condition fairly good; loss in my apiary 8 per cent., due largely to old queens; bees wintered one-half in cellar, others in

special cases made to hold two hives each with 6 inches sawdust; cases have slide cover in front to take out when putting hives in on the level; buckwheat and goldenrod honey given as winter stores; no disease present; alsike in good condition, but early frosts in 1907 killed half of the clover in our neighborhood; had to plow up 14 acres, and have only 10 left which was double seeded.

Oxford: Bees in fine shape; practically no loss; put in cellar from the 25th November to 10th December; no winter stores required; no signs of disease this spring; clovers came through the winter in good shape and other bloom is abundant.

Peel: Bees in fairly good condition, much better than last year; loss in my own apiary rather heavy, due to the dry fall, and on that account bees were not in good shape for winter; bees wintered outdoors in boxes, three hives to a box covered all around sides with 4 inches of leaves and with 6-8 inches of leaves on top; put in case early in November, taken out May 15th; sugar syrup fed quite largely for winter stores; some dysentery present; clover seems to be plentiful; alsike grown considerably but no other crops this season on account of dry weather.

Perth: General condition very good; loss through shortage of supplies 15 per cent.; wintered in single clamps packed with forest leaves put in about the 1st November, removed May 16th; honey fed for winter stores; foul brood in five colonies; clovers are all right; alsike grown to quite an extent; very little buckwheat, plenty of basswood when it yields.

Prescott: Bees in fairly good shape; loss 10 per cent.; wintered in cellar, put in November 8th, removed April 18th; sugar syrup fed for winter stores; some signs of dysentery among six colonies; wintered on honey alone; clovers came through fine, large amounts grown here, also basswood.

Prince Edward: Most colonies dead; what few are left in good condition; very backward in building up on account of cold spring; loss 65 per cent.; honey crop total failure here in 1907, many bees starved owing to long confinement and no flight from November 8th to April 23rd, and bees flying out up to May 18th perished owing to cold winds and rain. Bees wintered in repository above ground; put in November 8th, removed April 23rd; sugar syrup fed for winter stores; clovers came through in good shape, prospects good; plenty of alsike and clover, and some buckwheat grown.

Renfrew: Colonies only in fair condition; loss here 30 per cent.; wintered in cellar, put in about November 15th; sugar syrup fed for winter stores, clovers came through in good shape.

Russell: Bees are in good condition now; about 15 per cent., loss caused by want of stores and queenless colonies; wintered in cellar, put in November 12th, taken out April 23rd, about ten days later than usual; sugar syrup fed if necessary with about one-third honey; a few colonies showed signs of dysentery in the spring; all kinds of clovers came through in fine shape.

Simcoe : Colonies having enough honey were in good condition; loss here 20 per cent., due to shortness of stores; wintered in cellar, put in 8th December, taken out second week in April; about 40 lbs. of honey left with each colony in the fall; foul brood in two hives; owing to trying season last year, clover crop is very small, about 20 acres within reach of my bees; not as much clover grown as formerly.

Victoria : Strong colonies are building up fairly well and weaker ones held their own, very weak ones dwindled badly on account of cold and wet; loss in six apiaries here 40 per cent.; wintered in clamps, four in clamp with 3 inches dry sawdust around and 6 inches on top; most of us found enough fall honey in the hives for winter stores, but where fed with sugar syrup, the queens are mostly alive now; the queens that died had more or less dysentery; foul brood present in this vicinity; alsike looks well generally, about ten acres grown on each farm; no white clover sown.

Waterloo : Only in fair condition; loss 20 per cent., caused by dysentery, and in some cases by starvation; bees partly in cellar and partly outside packed in chaff, four colonies in the case; put in cellar November 26th, removed on April 6th. Bee-keeping badly neglected here owing to failures of the last few years; not enough sugar fed, mostly honey; on account of dry fall last year, there is not much white clover; alsike looks good but more should be raised.

Welland : General condition good, and losses 5 per cent., caused by starvation and queenlessness; wintered in cellar, put in November 16-29, removed April 10-14; fed on sugar for winter stores; dysentery showing in colonies; clovers wintered well, white plentiful, not much alsike and no buckwheat here.

Wellington : General condition fairly good; loss 12 per cent. from dysentery; wintered in cellar, put in November 20th, out April 25th; fed on honey for winter stores; clovers fairly good shape, alsike grown to a considerable extent.

Wentworth : Colonies in good shape; loss 15 per cent., due to starvation and failing queens; wintered partly in cellar and partly outside, packed in chaff; poorest colonies among those from the cellar; put away November 20th, started putting out on the 12th March, a few each day that was suitable, finished about April 1st; winter stores largely buckwheat honey, but also fed 300 lbs. sugar; some little signs of dysentery owing to cellar getting too warm; white and alsike clover never looked better.

York : Colonies seem in fair condition; loss 12 per cent. here, due to dysentery and spring dwindling; part wintered in cellar, balance outside in double hives packed with sawdust; put away latter part of November, taken from cellar early April; sugar generally fed for winter stores, but small quantities of honey mixed with it; some swarms showed dysentery; alsike clovers in very good shape, and this is about the only crop grown here.

Ontario Department of Agriculture.

DAIRY BRANCH.

Mitchell-Walker Moisture Test

By J. W. MITCHELL, B.A., Supt. Eastern Dairy School, and
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School.

In October we began work on the problem of rapid moisture determination in dairy products. Owing to the increasing demand, of late years, for a practical moisture test to be used in creameries and cheese factories, not a few methods have appeared attempting to meet this demand. We examined the reports of others upon the various moisture tests that are on the market, and in addition fully investigated a number of them ourselves. We concluded that the only feasible methods were the beaker method and Gray's test. The beaker method consists in weighing accurately into an aluminum cup a small quantity of butter, heating it over an alcohol flame till the moisture is all driven off, allowing to cool and reweighing. The loss in weight represents the moisture. From this the percentage of moisture in the sample is calculated. We found some undesirable features connected with this method, viz.,

(1) The necessity of having a very sensitive balance with attached weights, or else having a cheaper balance with separate weights which are rather tedious to use and liable to get lost in practical work in factories.

(2) The necessity of calculating from the weights obtained the percentage of moisture in the sample.

(3) The uncertainty as to the right moment to stop the heating.

(4) The care required to prevent loss by foaming or spattering.

(5) The uncertainty as to the right time to reweigh after heating, since if reweighed when still warm a wrong result is obtained, and if allowed to stand too long in the open air before reweighing the dried sample absorbs moisture from the air, and hence again a wrong result is obtained.

(6) The necessity of weighing accurately to the second decimal place, in grams, to give a sufficiently accurate result.

Upon the whole we concluded that this method, which has been considered by several chemists of note as the best rapid test yet offered, although quite reliable in the hands of a careful worker in a chemical laboratory, is not suitable in the hands of the average man. Not to our knowledge has it ever been used or recommended for work with curd. We tested it with curd and found it to work fairly well, but of course the above-mentioned objections, with the exception of number 4, still hold here. Several modifications of the beaker method have appeared from time to time.

Gray's test, consisting of heating a ten gram sample of butter with a mixture of amyl acetate and amyl valerianate in a glass flask, to which are attached a glass condenser and graduated receiver reading in percentages, presented none of the above difficulties; but we found several objections to it of a much more serious nature. It gave, with us, readings, altogether false as compared with the official method, concerning which there is no doubt whatever as to its reliability. Further, so much care is required to prevent loss of moisture through the open graduated neck and to guard against the breaking of a comparatively expensive and fragile piece of glassware, that these points themselves would tend to militate against its use in a creamery. In addition, the apparatus requires putting the different portions together and taking them apart again for each test. Lastly, the reagent used is rather expensive for practical use, since it cannot be used over again.

Since Gray's form of apparatus appeared on the market a so-called "improved form" of it has been brought forward. We tested this, also, but found it more fragile, rather cumbersome, and requiring considerable time and trouble to clean, although it gave more accurate readings than the original form. This greater degree of accuracy is due to a modified form of graduation of the scale. The errors in the results with the original form of Gray's test are due, chiefly, to absorption of moisture by the reagent used and not to any lack of condensation, providing sufficient care is taken in conducting the test.

Being dissatisfied with all the methods investigated by us, we undertook to work out a form of moisture test that would prove more satisfactory. We decided that the following requisites were necessary, and we kept them continually in view during our work:

- (1) A rapid and reasonably accurate method.
- (2) An inexpensive form of apparatus, both to purchase and to use.
- (3) A durable form of apparatus and one easy to clean.
- (4) A method that requires no great amount of attention or care in operating, and that can thus be used by the average factory man.
- (5) An apparatus than can, if damaged, be easily repaired at small cost.
- (6) A method equally suitable for testing butter, curd and cheese.

The next thing to decide on was, of course, the underlying principle to make use of. The only one that appeared to warrant development was that of using a reagent, expelling the moisture with heat, condensing the vapor and collecting it in a vessel graduated to read directly in percentages.

The next points to settle were the best form of apparatus and the best inexpensive reagent to use.

At the outset we determined to use metal in the apparatus, so far as possible, rather than glass, owing to the danger of breaking the latter, and to use no rubber connections. We thought to make the condenser and heating flask of aluminum, if possible, owing to its many desirable qualities. As no satisfactory solder for aluminum has, as yet, appeared we could not attach an evaporating cup to the condenser, unless we used some form of shoulder-and-nut connection, which did not seem altogether desirable, nor could we attach an inner condenser tube to an outer water jacket unless we used rubber stoppers at the ends. Further, upon experimenting to determine the effect, if any, of reagents upon sheet aluminum, we found that the aluminum became roughened too much to warrant its use as an inner condenser tube.

We then tested the effect of reagents on other metals, finding that block tin showed no ill effect whatever. We decided then to use a block tin tube for the inner condenser tube. This was sufficiently cheap, and could be easily soldered to the outer water jacket and to the evaporating cup. We had the outer water jacket made of thin sheet brass. The best size of tin tubing to use had to be determined by experiment and also the size of the water jacket.

We decided that to insure complete condensation of the water, without making the condenser too cumbersome, the vapor should be driven downward instead of upward. This would thus insure the lower part of the condenser being cold, since the warmed water would remain at the top. We wished further to have a condenser large enough to hold sufficient water not to need refilling under average conditions in a factory.

The object of using a reagent was to have something to keep the butter from foaming too much during the heating process, to help carry the condensed moisture out of the inner condenser tube, and to wash the tube out thoroughly afterward. We tested the use of amyl butyrate at this stage, since it was almost insoluble in water and was sufficiently volatile for part of it to be driven off with the moisture, and at the same time had a boiling point sufficiently high for part of it to remain after all the moisture was expelled from the sample, and pass over later to serve as a wash for the inner condenser tube. We were unable to procure a suitable metal evaporating cup at first, and in the meantime used a glass flask, connecting it with the condenser by means of a perforated rubber stopper. We used the condenser in a slanting position at first, but found that in this position the inner tube did not become thoroughly

washed out by the reagent. We then used it in an upright position. This modification and the use of an inner tube of suitable bore, formed a combination that worked admirably, causing the inner tube to flush quickly and thoroughly. It necessitated considerable experimenting to ascertain the best size of inner tube to use, one neither too large nor yet too small in bore, as each extreme presented its own difficulties.

The graduated receiving vessel had, of course, to be made of glass. We tried several forms and sizes, finally adopting that shown (and marked C.) in the illustration appearing in the bulletin. The oval-shaped, wide-mouthed upper portion forms a suitable receiver for the condensed moisture and reagent and a reservoir for the latter, while the constriction and outward curvature at the mouth and the spring wire clamp on the bottom of the condenser form a combination for readily attaching the receiver to the condenser and just as readily detaching it. The tube forming the lower portion of the receiver is of suitable bore to be graduated for reading per cent. of moisture for the size of sample taken, while the stop-cock at the bottom is for emptying purposes.

We wished to have the whole apparatus so constructed that it could be readily taken apart and packed for use by travelling inspectors, and in this we feel that we have been singularly successful.

For the purposes of this test, we found that a sufficiently accurate, and otherwise suitable, balance was obtainable at a reasonable price, thus making the whole apparatus really no more expensive than would be a balance alone which would be sufficiently accurate to be used in connection with any of the beaker tests, since they necessitate the use of a balance that will weigh accurately, in grams, to the second decimal place. To facilitate the work of readily balancing the cup on it for weighing the sample we devised a counterpoise to be attached to one of the arms of the balance. (See illustration.) This saves time in the weighing of the sample, making it a very quick process.

We felt that the only problems left to solve were those of getting a suitable metal evaporating cup, and of satisfying ourselves with regard to the reagent to use. After some difficulty we succeeded in getting a cup of thin sheet copper made by the spinning process, thus eliminating the use of solder, which would melt under the heat applied. We had considerable difficulty in getting a satisfactory steam-tight joint in the cup, however, but we have proved that the one we are now using is perfectly reliable. The form of cup is cylindrical, which renders it easy to weigh the sample into and to clean.

The problem of the best and cheapest reagent to use proved to be the hardest of all to solve. The main difficulty, outside of the feature of expense, lay in the fact that all the reagents we tried (and we tried many) seemed to absorb part of the moisture driven from the sample under the test, and thus delivered a shortage of water, and caused the readings to be too low. We had the receiving tube graduated to read

in percentages, providing a ten gram sample were used and all the moisture were recovered, that is, a volume of water recovered measuring one cubic centimetre would read ten per cent. on the scale of our receiver. After obtaining no reagent that would deliver all the water we concluded that we would have to just decide upon some one reagent, and compare the results from its use with those obtained from the official method; that is, heating a very accurately weighed sample in a water oven to constant weight, reweighing and calculating the percentage of moisture from the loss in weight from the heating process. Now, amyl butyrate seemed to be a fairly desirable reagent, although it had some undesirable features, namely, that it was rather expensive—especially the chemically pure product; its boiling point was rather high, requiring a longer time than we thought desirable to drive enough of it over to wash out the inner tube of the condenser, and its odor, although pleasant under ordinary circumstances, proved to be disagreeable when heated with butter, or when in contact for any length of time with the hands. We tried a large number of reagents, among which were eucalyptol, amyl acetate and various distillation products of crude petroleum. In choosing a reagent we had to consider the various requisites of one suitable for our purpose, namely, its boiling point, specific gravity, ability to prevent foaming of the sample, stability under the conditions to which it would be subjected, its suitability for flushing the inner tube of the condenser and finally its cost. Although we could easily have chosen a reagent consisting of a mixture of substances which would have performed the work well enough, yet, as we were anxious to use our reagent over and over again to reduce the expense of testing, we had to discard the idea of a mixture, since the constituents of highest boiling points would partly remain behind in the evaporating cup, thus altering the composition of that portion of the reagent recovered. We finally concluded that amyl acetate, when chemically pure, fulfilled these requisites in the largest measure.

After thus getting our method approximately complete, we concentrated our efforts upon solving the problem connected with its accuracy. We first used it with butter, and after making an exhaustive number of tests with this product we discovered that the *loss of moisture due to the reagent approximated a constant quantity, rather than being proportional to the percentage of the moisture in the samples*. We next used our test with curd and cheese and found the same principle to hold here also. The explanation of this appears to us to be that the moisture lost is that absorbed by the portion of the reagent that volatilizes with the moisture, the balance of the reagent being recovered in a moisture-free condition.

We thus found it necessary to correct the graduations on the receiving tube accordingly, so that it now gives readings closely approximating the results obtained by the official method, as may be seen from an examination of the table of results obtained by us.

RELIABILITY OF THE TEST.

That the test is reliable and more than approximately accurate is evident from the results recorded in the following tables :

Butter Samples.	Gravimetric Method.	Rapid Method.	Curd Samples.	Gravimetric Method.	Rapid Method.
1	11.62	11.7 11.8	1	39.6	39.6 39.6
2	15.31	15.3 15.4	2	55.38	55.4 55.4
3	12.38	12.4 12.5	3	53.12	53.2 53.0
4	9.90	9.8 9.8	4	49.07	49.2 49.4
5	14.50	14.4 14.4	5	61.83	61.8 62.0
6	10.83	10.95 10.95	Cheese Samples.		
7	11.64	11.65 11.7	1	30.53	30.4 30.2
8	19.53	19.6 19.6	2	35.0	34.8 34.6
9	16.77	16.7 16.7			
10	12.10	12.2 12.2			
11	12.08	12.0 12.1			
12	14.0	14.1 14.1			

RAPIDITY OF THE TEST.

Our methods of preparing the samples are very simple, reliable and rapid, while the thin, metal evaporating cup and the style of condenser used permit of rapid evaporation and insure condensation of the moisture without danger of either breakages or loss of moisture.

The time required for driving all the moisture from a sample of butter or curd is from four to seven minutes.

TEST SIMPLE TO CONDUCT AND APPARATUS EASY TO CLEAN.

An examination of the cut and a reading of the description of the test and the directions for conducting it will satisfy the reader as to its simplicity. The apparatus is simple in all its parts, while a single reagent, *not a mixture*, is used in the test.

There are very few pieces to clean and these are so constructed as to facilitate the work of cleaning them. The size and shape (cylindrical) of the evaporating cup render it very easy, both to fill and to clean,

while the reagent prevents the sample from adhering to it. All other parts are just as easily cleaned.

SMALL COST OF CONDUCTING A TEST.

The chief item of expense, in conducting a test, is the reagent used. This we have succeeded in reducing to a minimum through making provision for using the reagent over and over again. The average cost per test for both butter and cheese is somewhat below half a cent.

DURABILITY OF THE APPARATUS AND COST OF REPAIRS.

Practically the whole of the apparatus is made of metal—the evaporating cup, the condenser and the spirit lamp—and, in addition, it is made in sections. It is thus seen that the apparatus is durable, the chances for breakages are slight and repairs can be made at a trifling cost. Everything considered, the apparatus is an economical one both to purchase and to use.

OTHER USES FOR THE TEST.

While originally designed for use in connection with cheese and butter making, the test will doubtless serve a much wider field than that for which it was devised. We have used the apparatus for determining the percentage of moisture in flour, bread, breakfast foods, wood pulp, etc., with good results.

EXPLANATION AND DESCRIPTION OF THE TEST AND APPARATUS, AS SHOWN IN THE ACCOMPANYING ILLUSTRATION.

EXPLANATION OF THE TEST.

A representative sample of the substance to be tested having been obtained, the required quantity of it, 10 grams of butter or 5 grams of curd or cheese, is weighed into the evaporating cup A. To this is added the reagent. After connecting the cup with its cover the moisture and reagent are evaporated by means of the spirit lamp E. The vapors are condensed to liquid form again in passing through the small tube b₂, of the condenser B—this small tube being surrounded by cold water—and the condensed moisture and reagent flow out of the condenser into the graduated glass receiver C. As the water and the reagent do not mix, the water, which is the heavier, settles to the bottom of the graduated tubular neck of the receiver.

The scales on this neck are graduated for reading, directly, the per cent. of moisture in a sample when either 5 or 10 grams are taken to a test.

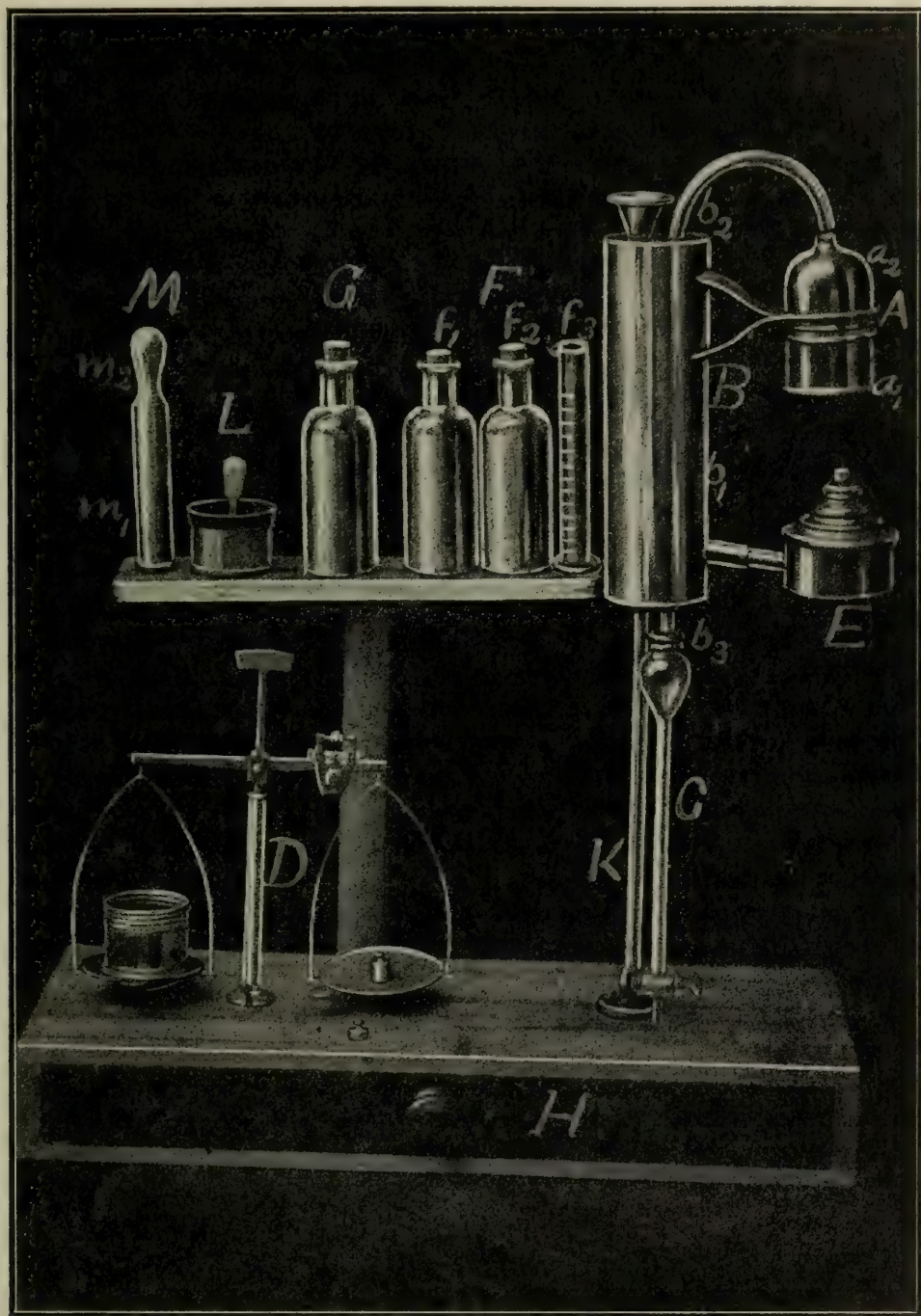
An examination of the accompanying cut shows the whole apparatus—lamp, cup, condenser and receiver—to be supported, when in use, by the upright K, which screws into a plate on the top of the base H. Once the sample is weighed and the heat applied the work goes on almost or quite automatically; and as there is no delicate glassware that requires close attention and no danger of the escape and loss of any of the moisture, the operator is at liberty, during the short time that it takes to evaporate the moisture, to attend to other small duties, if circumstances call for it, as they frequently do.

The reagent used serves several purposes. It prevents foaming and keeps the sample from adhering to the bottom of the cup or charring unduly; a portion of it passes over with the moisture and aids in carrying it both out of the condenser and down the receiver; while the high boiling point of the reagent causes a portion of it to remain behind in the cup, pass over later and thoroughly wash all the moisture out of the small tube of the condenser. This last is very much facilitated by the upright position of the condenser.

DESCRIPTION OF THE APPARATUS.

- A. Evaporating cup (metal).
 - a1. Evaporating cup proper.
 - a2. Lid of cup.
- B. Condenser.
 - b1. Jacket of condenser for holding water.
 - b2. Block tin condenser tube through which the vapors pass to be condensed.
 - b3. Spring clamp for holding the graduated receiver, C.
- C. Graduated glass receiver. The condensed liquids flow into this, the water settling to the bottom of the graduated tubular neck. The receiver has two scales, one for reading per cent. for 5 grams and the other for reading for 10 grams.
- D. *Balance* for weighing the sample. The cup, A, is placed in one pan and is readily balanced by means of the counterpoise on the opposite beam. The weight is then placed in the other pan for weighing the sample to be tested.
- E. *Spirit lamp* (metal for evaporating the moisture from the sample.
- F. Reagent outfit.
 - f1. Bottle of reagent prepared for use.
 - f2. Bottle for receiving used reagent.
 - f3. Graduate for measuring reagent.
- G. Alcohol bottle for holding wood alcohol to be used in the spirit lamp.
- H. Stand or base for apparatus.
- K. Upright which screws into the base H.

L. Sampling cup and spoon for preparing sample of butter and transferring it to evaporating cup on balance.



M. Curd and cheese sampler.

m1. Cylinder for taking sample. It has a wire gauze on one end.
m2. Piston for forcing the sample through sieve or gauze on the end of m1, thus cutting it into fine particles.

DIRECTIONS FOR CONDUCTING TEST.

TO TEST BUTTER.

1. Set up the apparatus just as it appears in the cut.
2. Fill the condenser with cold water.
3. Obtain a representative sample of butter and place it in the sampling cup, L. Heat *carefully*, either in hot water or over the alcohol flame, stirring continuously with the spoon provided until the butter is all *melted to a creamy consistency*.
4. Place the evaporating cup, A, on the scale pan and balance it by means of the counterpoise on the opposite beam. Place the 10 gram weight on the other scale pan and after again stirring the sample thoroughly, transfer sufficient of it to the cup to exactly balance the 10 gram weight.
5. Using the graduate, f3, add 10 cubic centimeters (c.c.) of the reagent to the cup from the bottle f1.
6. Connect the cup with its lid a2.
7. Apply the alcohol flame (a fairly large flame) to the evaporating cup—the lamp can be readily adjusted by moving it on the upright. In about one minute the water and reagent will begin to pass over and drop from the condenser tube, b2, into the receiver, C. After all the water has been evaporated from the cup the reagent will cease, or almost cease, dropping for a moment and then begin again as soon as it has reached its own boiling point, which is higher than that of water. Continue to apply the flame until practically all the reagent is driven off and it ceases to drop freely from the condenser tube. By this means all the water is washed out of the condenser tube and the major portion of the reagent is recovered. Now swing the alcohol lamp to one side and *put its lid on*.
8. Immediately remove the receiver, C, cork its mouth and, taking it by the top, swing it carefully a few times to detach any drops of water that may be adhering to its sides. Read the percentage of moisture direct from the scale, taking the bottom of the meniscus between the water and reagent as the top of the water line. Should any particles of moisture still adhere to the side of the tube, or the meniscus be imperfect, the wire accompanying the apparatus can be used to remedy this.
9. Have two reagent bottles and label them 1 and 2.
No. 1 contains the reagent ready for use.
No. 2 is for the used reagent.
10. When emptying the receiver, C, first open the stopcock to allow all the water to run out, then close it and then hold the receiver over bottle No. 2 and allow the used reagent to run into it. The receiver, after being shaken, is ready for use again.
11. Bottle No. 2 is necessary for keeping the used reagent separate from the other, since it has absorbed a small amount of moisture from

which it must be freed before it can be used again, else it would give too high a reading. When the water-free reagent in bottle No. 1 has been all, or nearly all, used up, the used reagent in bottle No. 2 can be freed of moisture by filling the carefully cleaned evaporating cup with it, attaching it to the condenser and heating *until water ceases to drop* from the condenser tube. The drops of water are readily seen as they sink through the reagent in the receiver. Now remove the cup and empty its contents, which are free of moisture and ready for use, into bottle No. 1. Put the reagent in the receiver into bottle No. 2, as it contains moisture.

CAUTIONS.

1. Always empty the reagent in the receiver, C, into bottle No. 2.
2. Never use the reagent from bottle No. 2 for testing; use only that from bottle No. 1.

TO TEST CURD AND CHEESE.

The directions for testing curd and cheese are similar to those for butter with the exception of the following: The sample is taken by pressing the cylinder, m₁, into the curd in the vat or into the cheese, as the case may be, twisting it round and pulling it out. The sample will be found in the cylinder. Be sure to obtain as representative a sample as possible. The piston, m₂, is now pressed in, thus forcing the sample through the sieve on end of cylinder, m₁. The sample should be pressed through the sieve once more to reduce it to a fine state of division. Stir the sample with the spoon and transfer it to the evaporating cup on the balance, *using five grams to a test.*

Use fifteen cubic centimeters of the reagent for curd and cheese and add a small piece of paraffin wax to the cup to prevent the sample from adhering to the bottom. After the test the curd or cheese is readily removed by means of the spoon whose upper end is specially fitted for this purpose.

No great care need be taken in cleaning the cup after a test, since it contains no moisture and can be easily balanced on the scale pan by means of the counterpoise. Simply wipe it out with a dry cloth.

DIRECTIONS FOR CLEANING THE APPARATUS AND FILLING CONDENSER.

The condenser need never be refilled with water unless several tests are made in close order. In this case empty the condenser when it becomes very warm about half way down and refill it with cold water.

The inner condenser tube must be cleaned after every few tests, with the flexible brush supplied. This should be run through the tube, first in the dry condition and secondly moistened with the reagent. *Use no water in this operation.*

The receiver, C, may be cleaned in a similar manner, although it is advisable to *occasionally* clean it with a hot solution of washing soda, followed by alcohol and this again by a little of the reagent.

We could have made our directions very brief had it seemed advisable to do so, but we preferred making them sufficiently full and explicit to cover and make clear all points in connection with the test, and thus insure accurate results. This course will, we believe, be appreciated by users of the test.

After making a few tests the simplicity of the whole operation will be apparent.

ADDENDA.

Experience has shown us that the balance works better with the heavy part of the counterpoise below instead of above the beam, and we have altered it accordingly. Place the counterpoise on the beam so that it practically balances the cup. Finer adjustments after this has been done are made by means of the nut on the screw that projects beyond the beam.

Keep the glass stopper of the graduated receiver vaselined.

Experience with both a threaded and a friction joint on the cup has proven that the latter works the better.

When testing curd or cheese heat more slowly than with butter, taking from seven to eight minutes to drive the moisture off.

The reagent used in this test is amyl acetate (technical variety), and should be obtainable from any reliable druggist at about one dollar per pound. It should be put in the cup and tested for moisture, and, if necessary, freed from the same before using.

PRICE OF THE MOISTURE TEST.

The apparatus may be obtained from us at the following prices: complete outfit, including an 8 oz. bottle of reagent, \$13. Travelling case for outfit, \$2 additional. (This is furnished only when specially ordered.) In cases where the balance for weighing out samples is not wished, a deduction of \$3.50 from the above price is made. We recommend the use of the balance supplied, however, as it has a counterpoise to balance the cup, and is otherwise specially fitted for the work.

Individual parts may be obtained at any time at reasonable prices. Customers in Canada will be charged \$14 for the complete outfit, as parts of it have to be imported and duty paid thereon.

All orders, unless accompanied by the price, sent C.O.D.

Send all orders for apparatus to Supt. of Eastern Dairy School, Kingston, Ontario.

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

The Perennial Sow Thistle and some other
Weed Pests of 1908.

BY J. EATON HOWITT, M.S.A., DEMONSTRATOR IN BOTANY.

FOREWORD.

The discussion of the Weed Pests of 1908 is a matter of emphatic concern. Through investigation, wide correspondence, and the reports of visitors and Farmers' Institute workers, it becomes more and more apparent to the Department of Botany that the Province of Ontario, at large, is sorely menaced in its agricultural industry by the spreading of noxious weeds. They are usurping our fields and greatly increasing the cost of producing crops. In the majority of cases, they attain a foothold before they are recognized and combatted. Very often they secure entrance into clean land through the use of seed whose impurities are not known. Ignorance of weeds, like all other ignorance, is costly. They are an enemy that is fought better by fore-knowledge than after-skill. Every farmer should be warned and prepared to resist their entrance or their first sign of attack.

Recently in the Province of Nova Scotia when it was found that an influx of the Brown Tail Moth, that has caused much damage in the New England States, was imminent, the pupils in the schools were organized into a first line of defence. To resist the attack of weeds there is need for similar organized precaution throughout the country; not only through the scholars in the schools but by everyone concerned.

Mr. Howitt has been giving special attention to this weed problem. The following pages will be found timely and suggestive. The weed pest of 1908 for one man becomes the weed pest of 1909 and succeeding years for a widening circle of sufferers.

S. B. McCREADY.

Botanical Department, Ontario Agricultural College,

October, 1908.



Fig. 1. Spiny Annual Sow Thistle
(*Sonchus asper.*)

THE SPREAD OF NOXIOUS WEEDS.

In spite of the progress that agriculture is making in Ontario, a number of very bad weeds are steadily, and in some instances rapidly, spreading over the farms of the Province. This is due to various causes, chief among which are the following:—

1. The neglect of the great majority of farmers to make themselves acquainted with the appearance and habit of growth of the worst weeds in the Province, in order that they may attack and exterminate them when they first appear upon their farms. It is a comparatively easy task to root out and destroy a few bad weeds in a field, but it is an extremely difficult, tedious, and costly undertaking to attempt to clean a field which has become over-run with a creeping perennial, such as Couch Grass or Canada Thistle.

2. The failure to cut the weeds on the road sides, along the railways, in neglected fields, and in fence corners before they mature and distribute their millions of seeds far and wide.

3. That far too much impure clover, hay, and grain seed is sown, either through ignorance, carelessness, or false economy. It would not be an exaggeration to say that seventy-five per cent. of the clover and timothy seed sown in the Province contains in various amounts from one to a dozen different kinds of weed seeds.

4. That many new weeds are being brought into the Province as seeds in screenings from the elevators in the West. These screenings are ground in Ontario mills, mixed with corn, barley or oats and sold for feed as mixed chop. Many of the weed seeds are not crushed in grinding and thus find their way on to Ontario farms.

OBJECTS OF THE BULLETIN.

1. To give as much information as possible about the Perennial Sow Thistle with the hope of aiding all who have to contend against this most serious pest.

2. To call attention to and describe six other weeds which are gaining ground in Ontario. Some of these have but recently been introduced; others have been in the Province for some years; but more information is required about all of them, judging by the numerous enquiries received concerning them.

3. To give as much definite information as possible about the best methods of eradicating each of these pests.

4. To call attention to the necessity for united action upon the part of all engaged in farming in order that the Perennial Sow Thistle may be held in check.



Fig. 2. Perennial Sow Thistle (*Sonchus arvensis*).

THE PERENNIAL SOW THISTLE.

(*Sonchus arvensis*, L.)

This is by all means the worst weed in the Province of Ontario at the present time. It is found in almost every county, and upon almost every farm. So rapidly and so persistently is it spreading that in some parts of the Province it threatens to entirely over-run the fields and drive out the farmer. In spite, however, of its wide dispersal there are many who are not able to recognize this pest and who mistake it for its two comparatively harmless cousins, the Common Annual Sow Thistle and the Spiny Annual Sow Thistle. This should not be the case, as it is a very conspicuous weed, and differs markedly from the other two species. The Perennial Sow Thistle grows freely on a great variety of soils, but is especially troublesome on rich, low, damp land. It appears the first year in a field in scattered patches consisting of young plants, each plant made up of a rosette of leaves lying close to the ground, and thus, when numerous, they completely cover it. These young plants have but short underground root stocks, and are comparatively easy to destroy. The second year a large stem bearing numerous leaves and flowers is produced and the rootstocks grow long and send up quantities of new shoots. Once established in this manner, it is no easy task to destroy this pest.

Description: The Perennial Sow Thistle (*Sonchus arvensis*) is a tall, coarse growing perennial weed with deep roots and numerous thick, underground stems or rootstocks, commonly spoken of as "roots." Upon these at intervals of a few inches are borne buds which develop into new plants. The stem is smooth and hollow and the whole plant is filled with a bitter milky juice. The leaves are pointed, 4 to 12 inches long, deeply cut with the segments pointed backwards (runcinate), slightly prickly. The flowers, or more correctly speaking, the heads of flowers are about 1 to 1½ inches across, and bright orange in color. The involucre, or, as it is commonly called, the flower cup, and the peduncles or flower stems are covered with distinct, yellow glandular bristles. The seeds are dark reddish-brown in color, about ⅙ of an inch long, somewhat spindle shaped with blunt ends, and each surface bears a number of very deeply wrinkled, longitudinal ribs. Each seed bears at the top a tuft of white silky hairs (pappus) which, when dry, acts as a parachute and enables the seed to be borne long distances by the wind.

POINTS OF DISTINCTION BETWEEN THE PERENNIAL SOW THISTLE AND THE ANNUAL SOW THISTLES.

1. The Perennial Sow Thistle is a taller, coarser growing plant than either of the other two Sow Thistles.
2. The Perennial Sow Thistle has numerous underground rootstocks while the annual species have only fibrous roots. (See illustrations.)

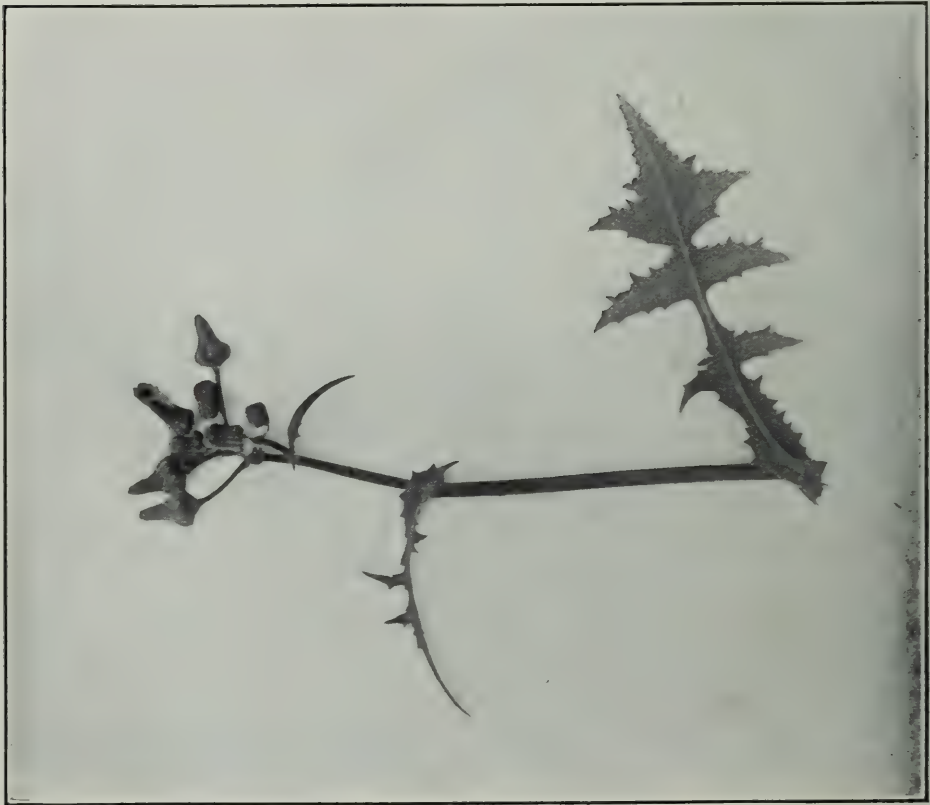


Fig. 3. Common Annual Sow Thistle (*Sonchus oleraceus*.)



Fig. 4. Fibrous root of annual Sow Thistle.



Fig 5. Leaf of (a) Common Annual ; (b) Spiny Annual ; (c) Perennial Sow Thistle.

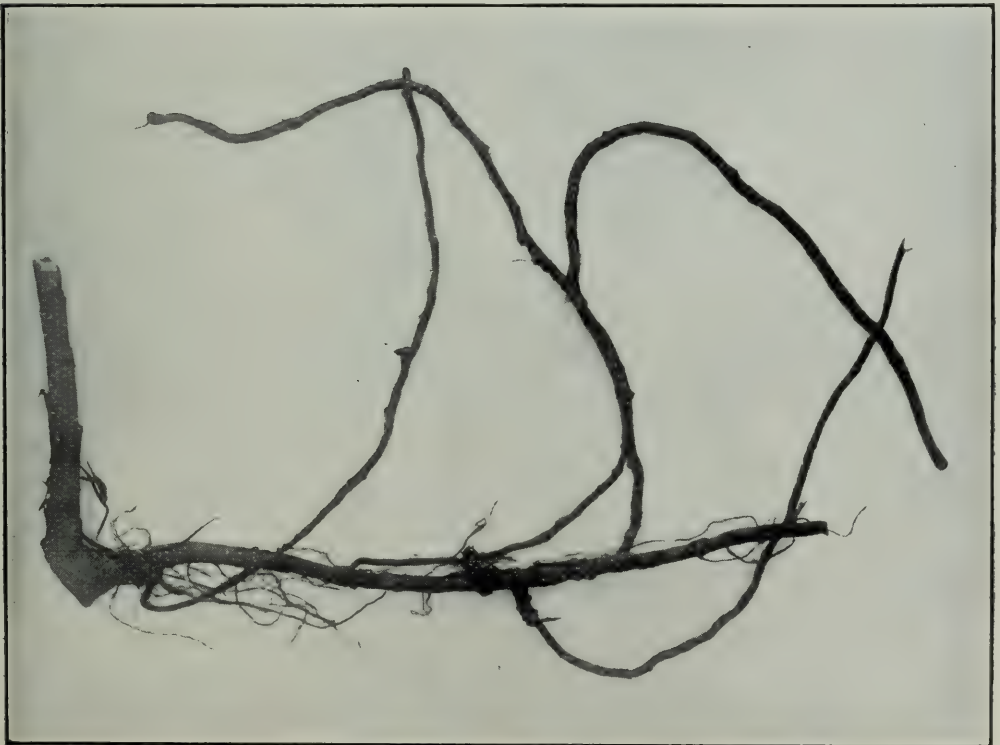


Fig. 6. Creeping "root" of perennial Sow Thistle.

3. The leaves of the Common Annual Sow Thistle are deeply cut and lobed and scarcely spiny. The leaves of the Spiny Annual Sow Thistle are almost entire, very prickly and often decidedly waxy. The leaves of the Perennial Sow Thistle are deeply cut, but not lobed and slightly prickly. (See illustrations.)

4. The "flowers" of the Perennial are bright orange in color and about $1\frac{1}{2}$ inches across, while the flowers of the Annuals are pale yellow and less than $\frac{1}{2}$ inch in diameter.

5. The "flower-cups" (involucres) and "flower stems" (peduncles) of the Perennial Sow Thistle are conspicuously covered with yellow glandular bristles while those of the annual species are nearly smooth.

6. The seeds of the three species also differ as to shape and markings as shown by the accompanying illustrations.

HOW THE PERENNIAL SOW THISTLE IS SPREAD.

The Perennial Sow Thistle is being rapidly and widely spread by means of its numerous seeds, which are blown far and wide by the wind, and to some extent by its abundant underground rootstocks which, with remarkable rapidity, spread through a field sending up new shoots which soon entirely cover the ground and choke out all other vegetation. The rootstocks when broken up are often carried from field to field by harrow or cultivator. It has been estimated that an average plant produces 2,000 seeds. There are thousands of these plants going to seed on neglected farms, on road sides and in fence corners. Many more mature plants are harvested with the grain and their millions of seeds scattered at threshing times. Is it to be wondered that the Perennial Sow Thistle is becoming such a serious pest in Ontario?

METHODS OF ERADICATION.

These are discussed under the headings of General Suggestions, General Methods and Detailed Methods.

GENERAL SUGGESTIONS.

1. Bear in mind that a few patches of Perennial Sow Thistle, if allowed to mature, may seed down a whole neighborhood. Therefore, take every precaution to prevent the seeding of patches in meadows, grain fields, fence corners, and on the road side.

2. Watch for the first two or three patches in the field and destroy them before the pest becomes established.

3. Be careful not to harrow or cultivate through patches and drag the underground rootstocks all over the field.

4. The Perennial Sow Thistle thrives most luxuriantly on rather low, damp land. Underdraining therefore will help to control it.

5. Sheep are fond of this weed, and, if turned on a field after harvest, will prevent its seeding and by their close cropping weaken the underground rootstocks.



Fig. 7. "Seed" of perennial Sow Thistle.
Enlarged about 12 times.



Fig. 8. "Seed" of common annual Sow Thistle.
Enlarged about 12 times.



Fig. 9. "Seed" of spiny Annual Sow Thistle.
Enlarged about 12 times.

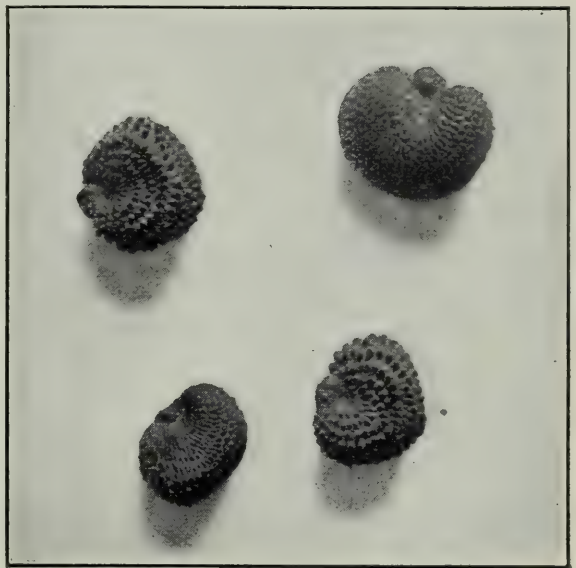


Fig. 10. Seeds of Bladder Campion.
Enlarged about 12 times.

GENERAL METHODS.

Crop Rotation. Crop rotation is of utmost importance in dealing with the Perennial Sow Thistle and other weeds of like nature. Some sharp, short rotation of crops should be adopted, which will allow of the frequent use of the cultivator, the cutting of the flowers before seeding, and the introduction of a smother crop or hoed crop. One cannot recommend a system of cropping which will be suitable in all kinds of farming. Each farmer must select the rotation which is most suitable to his conditions, keeping in mind those features of rotation which will best enable him to fight the Perennial Sow Thistle.

Smothering. The aim of this method is to kill the weed by depriving it of light and air. This is accomplished by getting some quick growing crop, such as rape or buckwheat, established on the land while the thistle is in a weakened condition. The result is that the smother crop soon occupies every available foot of the land and forms a dense shade in which the thistle in its weakened state cannot continue to grow. The same result is obtained by covering the plants with straw, dirt, leaves, etc., to a sufficient depth to prevent them from reaching the light and keeping them covered long enough to exhaust the "roots." This will require a year at least. Such treatment is of course only practicable in dealing with small patches.

Hoed Crops. The growing of such crops as potatoes, corn and roots, which allow of thorough cultivation and hand hoeing, provides a means by which many weeds may be effectively fought. Hoed crops alone do not give entire satisfaction in fighting the Perennial Sow Thistle. This is largely due to the fact that in cultivating and hoeing the rootstocks are cut, but not all destroyed and in a short time some begin to grow again. Hoed crops, therefore, are useful in keeping the pest in check, but should not be depended upon alone. They should be used in connection with other measures as outlined further on.

Summer Fallowing. This method is extremely efficacious with all sorts of weeds, including the Perennial Sow Thistle. By fallowing for this weed a bare fallow is understood or at least one which is given sufficient cultivation to prevent the pest from reproducing itself by means of seeds or roots. A neglected fallow is nothing more or less than a weed bed, and is useless and a source of contamination for every field on the farm. The chief objection to fallowing is the lying idle of the field for a season, but this is probably offset by the effectiveness of the method as compared with other methods which require a great deal more labor, time and attention. At the present time in Ontario many farmers are resorting to this method, considering it on the whole the most economical and most effective.

Digging by Hand. Small patches can be destroyed by digging out the plants with a fork, "roots" and all, and burning them. Great care should be taken to get every bit of the "root." The patch should be

watched, and if new shoots appear they should be taken out at once. In an ordinary season several diggings will be required in order to completely exterminate a patch.

DETAILED METHODS.

Several methods of exterminating the Perennial Sow Thistle are here outlined in detail. They have all been suggested by practical farmers. It is hoped that those who are looking for information on this subject will find among them a method suited to their own conditions.

Method No. 1. This method is suggested by Professor Zavitz, who found it effective in the eradication of Quack Grass. Cultivate the field until about the middle of June, running over it frequently with the cultivator so as to keep the tops down and thus weaken the "roots." Then apply manure at the rate of about 20 tons per acre (12 good loads). Cultivate the manure in thoroughly and with a double mould board plow slightly ridge up the land, making the ridges about 26 inches apart. On the ridges sow pasture rape at the rate of $1\frac{1}{2}$ lbs per acre. It is important that the right amount of rape should be sown, for if too little is sown the stand will not be thick enough to smother the weeds, and if on the other hand too much is sown the plants will be too crowded and not grow vigorously enough to keep ahead of the thistle. Sow the rape when the land is sufficiently moist to insure quick germination of the seed. If the rape is slow in starting the Sow Thistle may get a start in the rows and thus necessitate hand cultivation there. Cultivate the rape every week or ten days until it occupies all the ground and makes further cultivation impossible. If, when the rape is cut or pastured, any Sow Thistles remain, the field should be ridged up the last thing in the fall and put in with a hoed crop the following year. This should not be necessary if a good stand of rape is secured.

Method No. 2. This is a system of intensive cropping suggested by Professor Zavitz. As soon as a cereal crop is harvested, plow the land and give frequent cultivation to the first or middle of September. Then sow winter rye at the rate of about two bushels per acre. This can be pastured the following spring, or cut for hay or grain. As soon as the crop is off the land, put in rape, turnips or buckwheat. The advantage of this system is that three crops are harvested in two years and the Sow Thistle fought at the same time.

Method No. 3. This method is recommended by Professor Day. Immediately after harvest gang-plow shallow and run over the field several times with the broad shared cultivator. Later in the fall plow a little deeper, and continue cultivating every week or ten days as long as the season permits. Last thing before the ground freezes rib up the land with a double mould board plow. The following spring give frequent cultivation up to the first of July, then sow pasture rape.

Method No. 4. This is a short rotation which has been recommended by several Farmers' Institute workers. Clover is followed by a crop of grain, then clover again. The clover is cut in June, and the land plowed about four inches deep and given frequent and thorough cultivation during the rest of the summer. The following spring a grain crop is sown, seeding down with clover. For best results the grain crop should be one which can be cut early enough to prevent the thistle from seeding.

Method No. 5. Directly after harvest plow the land lightly, and then give frequent cultivation as long as the season permits. The following spring gang-plow, and leave in summer fallow until it is time to sow fall wheat. The summer fallow to be effective must be a *bare fallow*. The field must be cultivated thoroughly and frequently, with the object of keeping the tops down and breaking up and bringing to the surface of the ground as many of the "roots" as possible. The gang-plow should occasionally be run over the field in order to insure the cutting of the roots. Bare summer fallow has given excellent results on the College farm in seasons when other methods were at best only partially effective.

BLADDER CAMPION, COW BELL OR BLADDER WEED.

(*Silene inflata*, L.)

This is another bad weed which is becoming a serious pest on many farms in Ontario and about which a great many enquiries have been made during the past two years. It is spread chiefly as an impurity in clover seed. A large number of the samples of clover seed, especially those of red and alsike clover, sent to the Department of Botany this past season for examination as to purity, have been found to contain the seeds of this weed. As it is a free seeder, and very difficult to exterminate once it becomes established, too much care cannot be taken to secure clover seed free from this impurity, and to dig up by the roots and burn any stray specimens that by any means may find their way on to the farm.

Description. The Bladder Champion (*Silene inflata*) is a naturalized, deep rooted, freely branching perennial weed belonging to the Pink Family (*Caryophyllaceae*). It grows from six inches to two feet high. The leaves are ovate lanceolate, smooth, in pairs with their bases meeting around the stem. The flowers are white, nearly an inch in diameter and borne in loose clusters which are often drooping. The petals are two-cleft and the calyx much inflated and bell-shaped, with distinct purplish veins. It is from the inflated calyx that the plant derives its common names, Bladder Champion, Bladder Weed, and Cow Bell. The capsule or "seed pod" is enclosed by the inflated calyx and opens at the top by 5 short recurved teeth. This weed flowers from June to August and matures seed from July to September. Large quantities of seed are produced. They are about 1-16 of an inch in length, irregularly kidney-shaped, light brown to dark grey in color, the surface covered with regularly arranged rows of tubercles. Typical seeds show a marked

depression at the scar. This character, and the more conical shape of the tubercles, make it possible for a careful observer to distinguish them from the seeds of the Night-flowering Catchfly and White Cockle, which they resemble very closely.



Fig. 11. Bladder Campion (*Silene inflata*.)

Eradication. The roots of this pest are very long, thick, and much branched. A good-sized plant will have a root over two feet long with numerous deep rootstocks. A weed with such an underground root system is necessarily hard to combat. Some means must be taken by which the deep roots and rootstocks can be destroyed. Small patches should be carefully dug out early enough in the season to prevent seeding, taking pains to get every piece of the root and rootstocks. Badly infested fields should be plowed deeply immediately after harvest; and then thoroughly cultivated and cross-cultivated with the broad-shared cultivator in order to cut up and weaken the underground root system. The following spring continue this deep cultivation at intervals of about two weeks until it is time to put in a hoed crop, which must be kept thoroughly clean in order to be effective.



Fig. 12. Root of Bladder Campion.



Fig. 13. Stinkweed or Penny Cress.
(*Thlaspi arvense*.)
About $\frac{2}{3}$ natural size.

STINKWEED, PENNY CRESS.

(Thlaspi arvense, L.)

Though this weed is by no means new to the Province of Ontario, it is worthy of attention here as it is being constantly reported from new sections of the Province. It seems to be spreading through the agency of ground feed made from Western screenings and to some extent as an impurity in farm seeds. It is considered to be one of the worst pests of the grain fields of the West. Careful watch should be kept for it, as it is a very free seeder, and the seeds are said to have great vitality and to be able, like mustard seed, to remain in the ground for some years.

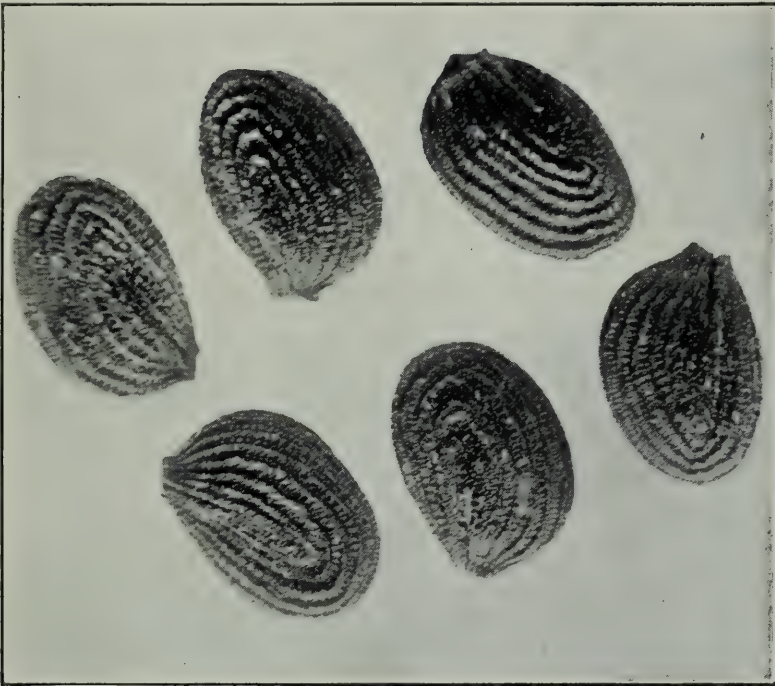


Fig. 14. Seeds of Penny Cress.
(Photo by Prof. M. V. Stingerland, Cornell Univ.)
Enlarged about 12 times.

Description. Stinkweed or Penny Cress is an annual or winter annual belonging to the Mustard Family (*Cruciferae*). It is a foul smelling plant from 1 to 2 feet high, bearing smooth, dark green, sessile leaves, and clusters of small white flowers, which develop into orbicular pods. These are flat, notched at the top, and about half an inch broad. It is from these peculiarly shaped pods that the plant gets its common name, Penny Cress. Each pod contains about a dozen seeds. The seeds are about 1-14 of an inch long, flat, irregularly oval, bronzy brown to metallic black in color, with regularly arranged curved lines on both surfaces.

Eradication. Hand pull and burn when in small quantities. If the field is badly infested the following method of eradication is recommended. **“Run a disk or harrow over the stubble as soon as the crop is removed, so as to start into growth the seeds near the surface. The following spring cultivate or harrow these plants down; and as soon as growth of fresh plants starts, plow the land and harrow at once. This land may be sown late to a green feed crop or it may be kept under a clean fallow for the whole season if the land can be spared. The following spring any growth of weeds should be cultivated down before sowing the crop.”*

Plants with fully formed pods should never be plowed down, as the seeds will mature below the ground and maintain their vitality for considerable time.

RUSSIAN THISTLE.

(*Salsola Kali*, var. *tragus*, Moq.)

This is a new weed which has appeared on many farms in Ontario during the past season. It has been introduced as an impurity in Alfalfa seed. A large percentage of the samples of Alfalfa seed examined at the Department of Botany this spring contained the seeds of this weed and already this fall several specimens of the weed, found in Alfalfa

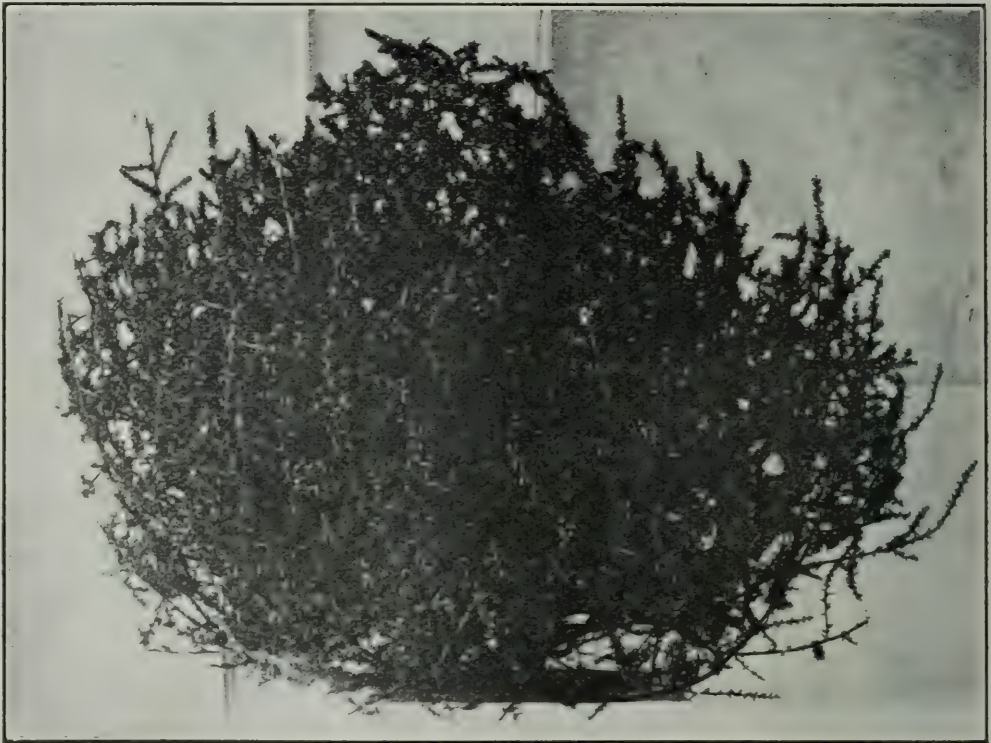


Fig. 15. Russian Thistle. (*Salsola Kali* var. *Tragus*.)

*Farm Weeds of Canada, by Geo. H. Clark and Dr. James Fletcher.

fields, have been sent in for identification. The Russian Thistle is a very serious pest in several of the Western States, and is found in the Prairie Provinces, but has not yet been reported as being very troublesome there. The plants, when ripe, break off at the surface of the ground and are rolled long distances by the wind, scattering their numerous seeds on their journey. It is this tumbling habit that makes this weed particularly adapted to the prairie lands of the West, and it probably will never be a serious pest in Ontario where fences, trees and other obstructions will prevent its being spread far and wide by the wind.

Description. The Russian Thistle is a native of Europe and Western Asia. It is a nearly smooth, bushy branched annual, from 1 to 3 feet high. Mature plants are more or less spherical in form. The stems and branches are red in color. The leaves are awl-shaped, one to two inches long, soft and fleshy when young, very prickly pointed when mature. The flowers are inconspicuous, being small, without petals, and solitary in the axils of the leaves. The seeds are about 1-12 of an inch long, obconical in general outline, with a cup-shaped depression at the upper end in the centre of which is a pointed projection, color dull grey or green, embryo spirally coiled.

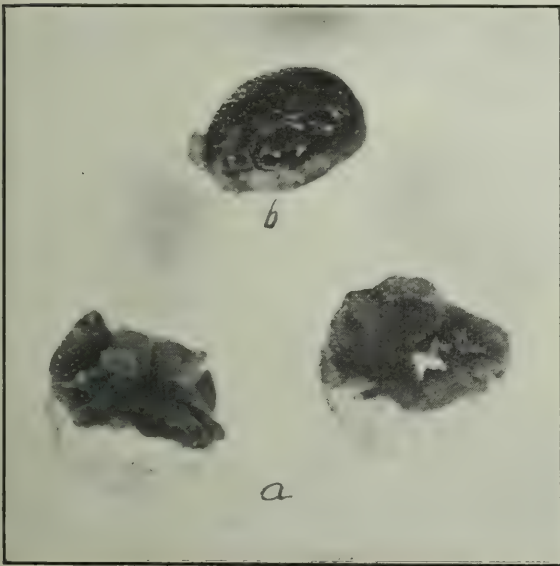


Fig. 16. Seeds of Russian Thistle.
(a) Complete seeds.
(b) Embryo.
Enlarged about 12 times.

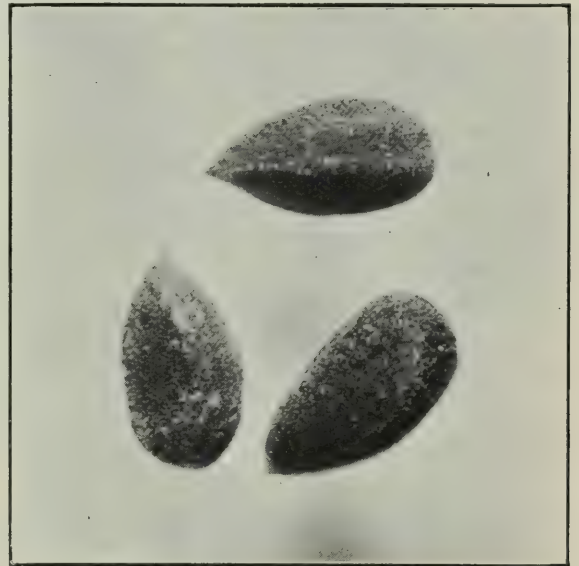


Fig. 17. Seed of Field Pepper Grass or Cow Cress.
Enlarged about 12 times.

Eradication. The Russian Thistle being an annual weed is not hard to exterminate. If once cut off at the surface of the ground it never grows again, and hence in well cultivated fields it is not likely to prove a pest. The chief danger lies in neglect. A single plant produces an enormous number of seeds, and if a few specimens are allowed to mature they will seed down a whole field and cause serious trouble the following year,

especially in a crop which does not allow of the frequent use of the cultivator. Farmers in Ontario should, therefore, be on the lookout for this weed and destroy any specimens they may find in their fields, fence corners, or along the road sides. If a field is neglected until it becomes seeded, repeated plowing will be required in order to clean it. **“When the plant is not more than six inches high careful plowing with a drag chain from the end of the doubletrees to the plow beam, dragging back so as to have every plant dragged under the furrow, with harrowing to fill every crevice between the furrows will destroy every plant that cannot get its leaves to the surface.”*

FIELD PEPPER GRASS OR COW CRESS.

(*Lepidium campestre*, Br.)

This is a comparatively new weed in Ontario, about which many enquiries have been received during the past two years. From information gathered from correspondents it seems certain that it has been spread as an impurity in clover seed.

Description. Field Pepper Grass or Cow Cress is an introduced annual or biennial weed belonging to the Mustard Family (*Cruciferae*). It grows from 1 to 2 feet high and branches freely above. The basal leaves are petioled, oblong and entire; stem leaves spear-shaped, entire or slightly toothed and clasping the stem by their arrow-shaped bases. Flowers are small, white or yellowish in color. The seed pods are broadly ovate boat-shaped, being rounded below and hollowed out above. They stand out stiffly from the stem on pedicels of about their own length. The seeds are reddish brown in color, about 1-12 of an inch long, sharply egg-shaped, rounded or somewhat flattened, and the surface is granular and slightly scurfy.

Eradication. Hand pull small patches. Cut clover early enough to prevent seeding. Plow up badly infested fields, and put in a hoed crop for one season.

DODDER, DEVIL'S GUT OR STRANGLE WEED.

(*Cuscuta epithymum*, Murr.)

This weed is spreading very rapidly, as an impurity in Alfalfa and clover seed. It is by no means a new weed in Ontario, but during the past year has been especially abundant. Judging by the numerous samples sent in for identification, and by the host of questions asked concerning it, more information is required as to its appearance, habit of growth and method of control. It is therefore discussed rather fully here.

*Bulletin No. 26, Iowa Agr. College Experiment Station, Ames, Iowa.



Fig. 18. Field Pepper Grass or Cow Cress (*Lepidium campestre*).



Fig. 19. Field Dodder on Red Clover. *a* Flowering Cluster; *b* Cluster of Dry Seed Vessels. From a photograph. Natural size.

(Reproduced by the courtesy of the U. S. Dept. of Agriculture, from Farmers' Bulletin 306 "Dodder in Relation to Farm Seeds," by F. H. Hillman.)

Description. Dodder differs from ordinary weeds in possessing no leaves. The yellow thread-like stems of the plant twine around the clover plants and send into their tissues small short rootlets, which are called suckers or haustoria. By means of these suckers the Dodder draws from the clover the food necessary for its growth and reproduction. It thus kills the clover by robbing the plant of its food and causing it to starve.

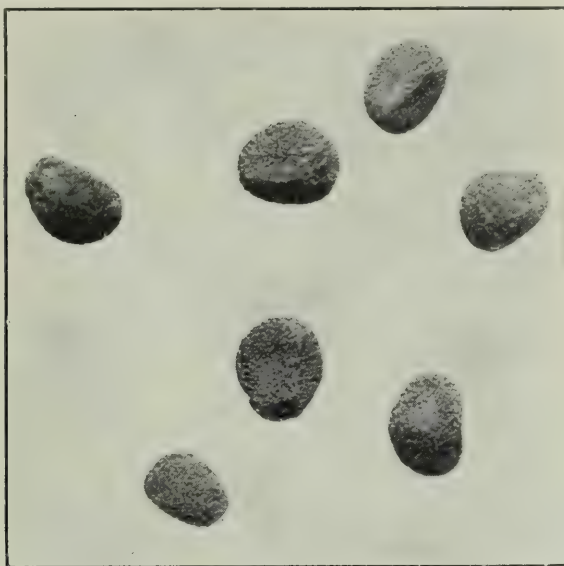


Fig. 20. Seed of Dodder.
Enlarged about 12 times.

The yellow thread-like stems of the Dodder first appear quite early in the season. They soon spread from plant to plant until a tangled mass of yellow threads covers a whole patch of clover. Badly infested fields may become entirely covered with this pest in a short time. On these yellow threads are produced dense clusters of small white flowers, which are succeeded by rounded, brown seed pods. Each plant produces a large number of seeds. The seeds vary in size from 1-24 to 1-15 of an inch; are grey or yellowish brown in color, vary greatly in shape, but are generally somewhat oval in outline, and the surface is dull and roughened.

Eradication. Great care should be taken to secure clover seed free from Dodder seed. Clover seed containing this impurity is dear at any price. Small patches should be mowed, raked and burnt early enough to prevent seeding. If, by any chance, some of the seeds are scattered before the patches are mowed, several thorough hoeings should be given in order to prevent any young plants from getting established. Badly infested fields should be plowed and put under a hoed crop for a season. Clover should not again be sown in the field for two or three years.

PAINT BRUSH, DEVIL'S PAINT BRUSH OR ORANGE HAWK WEED.

(Hieracium aurantiacum, L.)

This is another weed which is gaining ground in Ontario. It has been common for some time in the eastern part of the Province, but is now reported as being found as far west as Oxford County. It has been found in the vicinity of Guelph for several years. It is being dispersed as

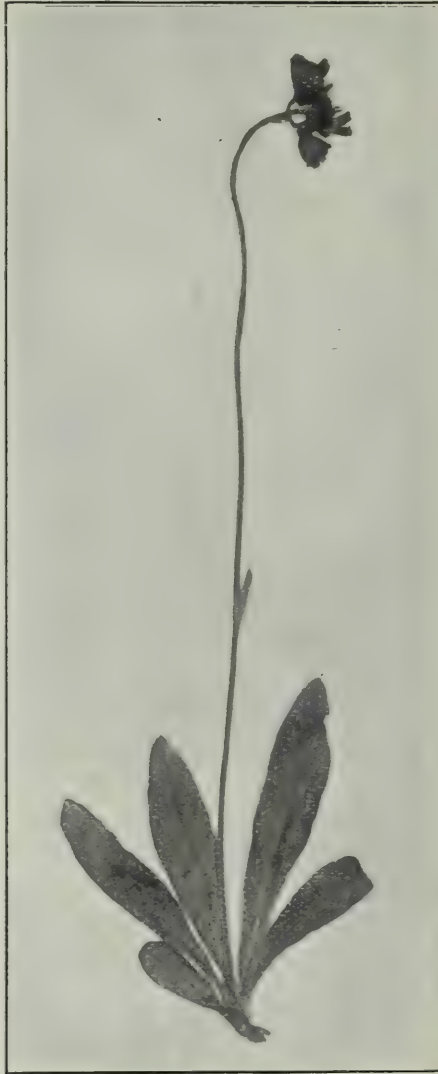


Fig. 21. Orange Hawkweed or
Devil's Paint Brush.
(Hieracium aurantiacum)

an impurity in clover seed, and by means of its tufted seeds, which are blown about by the wind. It is a serious pest when it gets into meadows and pastures, as it spreads rapidly by runners and soon crowds out the grass. Careful watch should therefore be kept to prevent its establishment upon the farms of Ontario.

Description. It is a perennial weed of European origin, and produces slender runners, which lie near the surface of the soil. The leaves are all basal, and lie close to the ground, forming a rosette. They are broadly lance-shaped, from 2 to 6 inches in length, the "flower" is orange red in color, about 2-3 of an inch in diameter, and borne in clusters on the top of a simple, nearly leafless stem from 12 to 18 inches high. The seeds are provided with tufts of down. When found in clover seed, however, the down is usually absent. They are torpedo-shaped, about 1-12 of an inch long, and ribbed lengthwise. Ripe seeds are dull jet black in color, unripe seeds deep red.

Eradication. Paint Brush is but a shallow rooted perennial, and readily succumbs to cultivation. Infested meadows and pastures should be broken up and put under a short rotation of crops. Salt at the rate of $1\frac{1}{2}$ tons per acre is recommended for the destruction of this weed. It should be scattered over the patches so as to fall on the leaves. It is claimed that it destroys the Paint Brush and improves the grass.

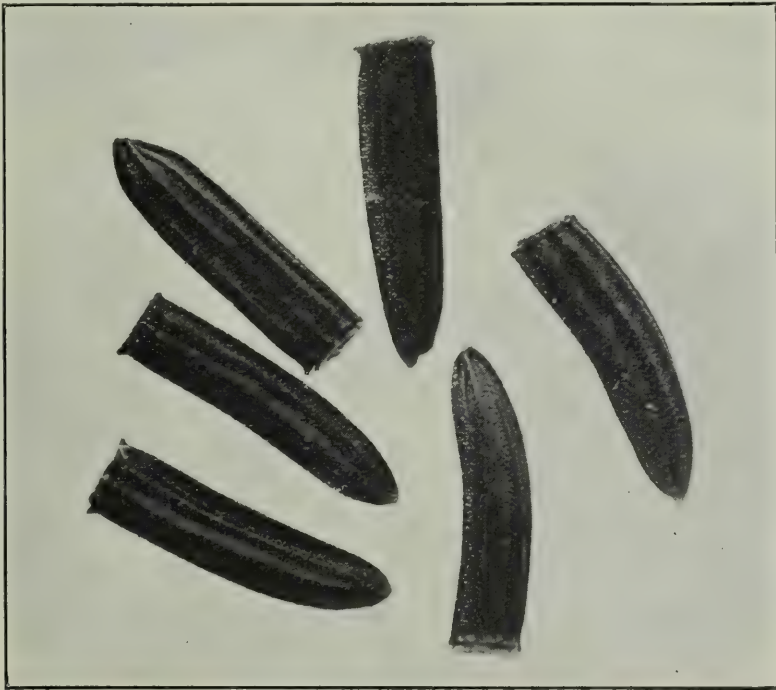


Fig. 22. Seed of Orange Hawkweed.
Enlarged about 12 times.

KNOW THE WEEDS.

It is very important that those engaged in farming should get to know the worst weeds, and the weed seeds most frequently found in commercial seeds. This they can do with a little trouble. Strange weeds should be sent to the Botanical Department here for identification and a collection of the most common weed seeds should be secured for reference and comparison. In order to aid farmers and others to test their

own seeds as to purity the Botanical Department will furnish at cost (25 cents) cases containing the weed seeds covered by the Dominion Seed Control Act of 1905, together with numbered lists of the names of the weed seeds they contain. These cases with lists can be had at any time by applying to the Botanical Department, O.A.C., Guelph.

MAGNIFYING GLASSES.

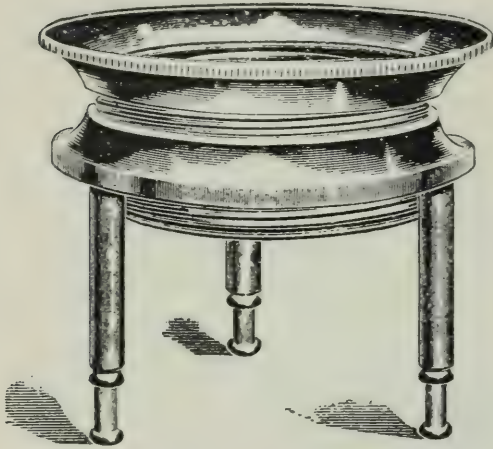


Fig. 23. Tripod Magnifier.

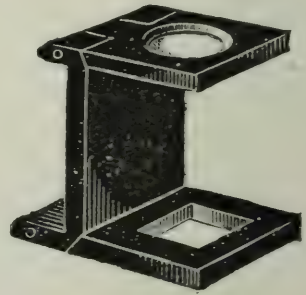


Fig. 24. Linen Tester.



Fig. 25. Watchmaker's Lens.

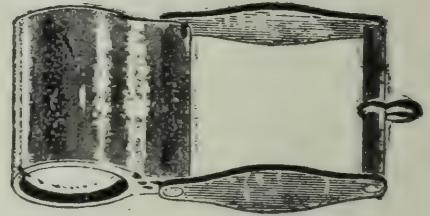


Fig. 26. Hand Lens.

A small magnifying glass is a necessity in identifying seeds. Several kinds of cheap glasses can be purchased at almost any jewellery store. Cuts of some of the best of these are given here. Perhaps the most convenient and cheapest glasses are the tripod magnifier and the linen tester.

WEED IDENTIFICATION AND SEED TESTING.

The Department of Botany is at the service of farmers, gardeners, seed merchants and others in the identification of weeds, weed seeds, plant diseases, grasses and economic plants. Clover and other farm seeds are tested and reported upon as to purity absolutely free of charge. Plant specimens and samples of seeds should be carefully packed and addressed with postage prepaid to the Botanical Department, Ontario Agricultural College, Guelph, Ontario.

Ontario Department of Agriculture.

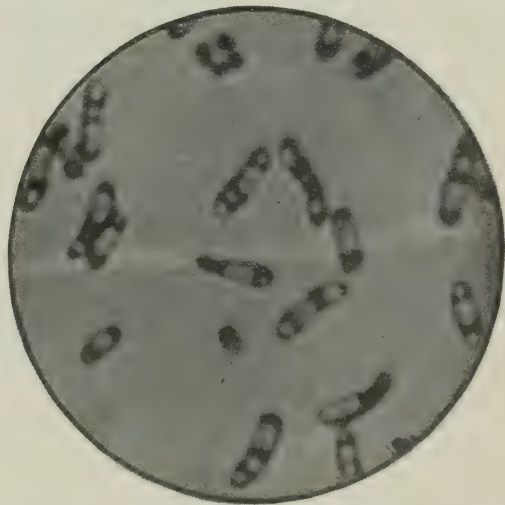
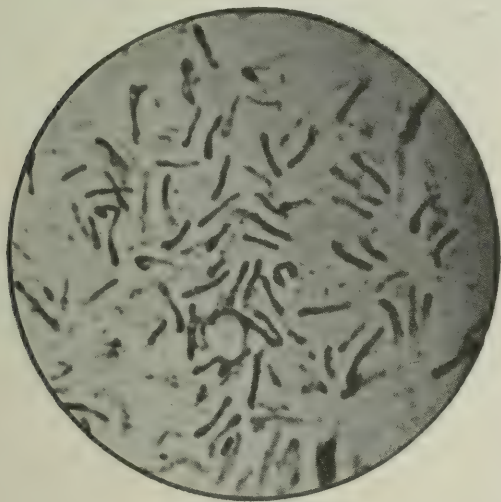
ONTARIO AGRICULTURAL COLLEGE.

LEGUME BACTERIA.

FURTHER STUDIES OF THE NITROGEN ACCUMULATION IN THE LEGUMINOSÆ.

By S. F. EDWARDS AND B. BARLOW.

Studies of the nitrogen accumulating bacteria, *Ps. radiculicola*, have been in progress in this laboratory during a period of about five years. The results of investigation up to 1906 were compiled and published by Harrison and Barlow in the Proceedings of the Royal Society of Canada, 1906, and in the Centrallblatt für Bakteriologie, II Abte., Vol. 19, 1907.



1. *Ps. radiculicola* from nodule of *Medicago sativa*, Alfalfa, showing both minute rods and large branched cells. Amyl-Gram stain. X 1,000.

2. *Ps. radiculicola* from nodule of *Medicago sativa*, Alfalfa. Bacteroidal cells only. Carbol-fuchsin stain. X 1,500.

Briefly the results embodied are as follows :

There were examined upwards of thirty foreign economic species of Leguminosæ of the sub-order *Papilionaceæ*, exclusive of some twenty-four species and varieties of the genus *Vicia*, also a number of native species. Nodules were found on the roots of all of these with the exception of two species, *Cicer arietinum*, and *Galega officinalis*. Plants

of the sub-order *Cæsalpinæ* were examined and no nodules were found on the roots of *Gimnocladus*, *Gleditschia* or *Cercis canadensis*, but mycorrhiza were present in all cases.

Ps. radiculicola was isolated from the following host plants:

TRIFOLIÆ:

Medicago sativa
Melilotus alba •
Trifolium incarnatum
Trifolium pratense
Trifolium repens.

HEDYSAREÆ:

Desmodium acuminatum
Desmodium canescens
Desmodium nudiflorum.

VICIEÆ:

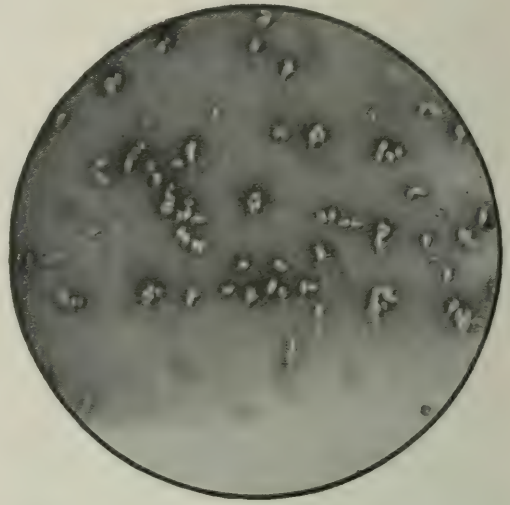
Vicia villosa
Lathyrus sativus
Pisum sativum.

PHASEOLEÆ:

Glycine hispida
Apios tuberosa
Phaseolus vulgaris.



3. *Ps. radiculicola* from nodule of *Medicago sativa*, Alfalfa. Only small rod forms were present. Saturated alcoholic gentian violet stain. X 1,000.



4. *Ps. radiculicola* from *Medicago sativa*, Alfalfa. Culture on ash-maltose-agar, showing polar flagella. Saturated alcoholic gentian violet stain. X 1,000.

MEDIA FOR GROWTH OF *Ps. radiculicola*.

Various media were tried, and it was found that the organism grew luxuriantly in an ash-sugar-agar, prepared as follows:—

“To 1000 c.cm. of cold water, either tap or distilled, add 2.5 g. to 25 g. wood ash; stir in and filter at once, or at any time up to one-half hour. Or the ash may be added to boiling water, boiled a minute or two and filtered at once. The filtering may be done through a tuft of absorbent cotton at the pump. The filtrate should be clear and colourless and should be more alkaline to phenolphthalein as the amount of ash or the time before filtration is increased. The acidity at this point was found to vary from very faintly alkaline to 17.5° acid to phenolphthalein. At this point agar is added in amount from 0.5% to 1.5%. The agar is added to the ash filtrate and the mixture boiled over the

flame with stirring, or heated in flowing steam or the autoclave until the agar is all dissolved. Maltose is now added in amount from 0.4% to 4%. The medium is heated for a few minutes or allowed to stand until the sugar is thoroughly dissolved, when the medium is filtered through absorbent cotton at the pump. Sterilization may be affected either in flowing steam or in the autoclave.

"If a liquid medium is desired, the same procedure is followed, except that the agar is omitted."

Ashes from maple or mixed beech and maple, from elm and from tamarack were used with equally favourable results.



5. *Ps. radiculicola* from nodule of *Melilotus alba*, White Sweet Clover. Cuneate and branched cells. Amyl-Gram stain. X 1,500.



6. *Ps. radiculicola* from nodule of *Melilotus officinalis*, Yellow Sweet Clover. Small rods and much branched cells. Amyl-Gram stain. X 1,500.

This medium contains from the ash, all the mineral elements required for bacterial growth, the sugar is the source of energy, and the nitrogen is secured from the atmosphere. The nitrogen accumulating power of the organism is thus maintained.

The tabulated summary of media used follows:—

Tabulated Summary of Media.

Water 100.

Agar None.								Agar 1 per cent.								
Medium R..	31	32	33	45	42	49	50	35	44	46	48	34	46.1	36	37	47
Ash.....	1	1	1	1	1.5	1	2	1	1	1	2	1	1	1	1	2
Maltose....	.....	.....	.....	2	.....	1	1	2	2	1	2	.....	.....	2	0.5	1
Sucrose....	.....	2	2	.....	.....	.....	.....	.....	.....	.....	.....	2	1	.....	2	.....
KH ₂ PO ₄...	.....	.....	0.5	0.2	0.5	2	2	.....	.....	.....	.....	.....	.....	0.5	0.5	1
To Litmus..	-11°	-10°	+11°	+4°	Alk.	+28°	+28°	-5°	N.	N.	N.	-5°	-5°	+	+	+2°
To P'thalein	-8°	-6°	+31°	+19°	.....	+93°	+63°	-2°	..	N.	N.	-2°	-5°	+	+	+18°

N—Neutral.

Alk.—Alkaline.

Tap Water 100.

Medium R.....	74	76	77	78	80	81	82	83	51
Agar.....	1.5	1.2	1.5	1	2	1.5	1.2	1.2	0.75
Maltose.....	2	2	2	1	1	1	.....	.25	1
Ash.....	.66	.66	.75	1	.5	1	.25	.25	.5
To Litmus.....	Alk.	.....	.....	-10°	.....	.....	.....	.....	.....
To P'phthalein.....	Neut.	-2°	Alk.	-2°	.....	.....	.....	.....	.....

Distilled Water 100 ; Maltose 1 per cent.

Agar None.			Agar 1 per cent.			Agar 1.5 per cent.		
Ash	Reaction	Stock R	Ash	Reaction	Stock R	Ash	Reaction	Stock R
0	+1°	52	0	+3°	53	1	-5°	59
0.5	+1°	54	0.5	-2°	55	1.5	-7°	70
1.0	-2.5°	56	1.0	-2°	57	0.5	-4°	71 Tap W.
1.5	-3°	58	1.5	-2°	59	1.0	Alk.	72 Tap W.
2.0	-4.5°	60	2.0	-2°	61			
2.5	-6°	62	2.5	-2°	63			
0.5 Faintly Alk.		68	3	-8°	64			
0.5		73	4	-13°	65			
0.5		79	5	-21°	66			

Ash 1, Maltose 1, Agar 1.			Ash—Maltose—Water.				
Water	Reaction	Stock	Water	Ash	Maltose	Reaction	Stock
100 tap	+1°	R 87	100 dist.	0.5	0.5	-0.5°	R 90
100 dist.	.....	R 97	100 dist.	0.5	0.5	-0.2°	R 91
100 dist.	-2°	R 98	100 tap	1	1	.....	R 92
100 dist.	.....	R 99	100 tap	1	1	.....	R 93
100 dist.	.....	R 100	100 dist.	1	1	Neut.	R 95
100 tap	Neut.	R 101	100 tap	1	1	.....	R 96
100 tap	.....	R 102					

Similar media were used for growing legumes in 1½ L. Erlenmeyer flasks. Seeds of legumes were secured from the pods under aseptic conditions, and grown in Erlenmeyer flasks for studies in inoculation with pure cultures. Figs. 31 and 32.

Since the publication of the previous work, we have examined the nodules and found bacteria present in additional host plants, as follows:

TRIFOLIÆ:

Medicago lupulina
Melilotus officinalis
Trifolium hybridum
Trifolium procumbens.

GALEGEÆ:

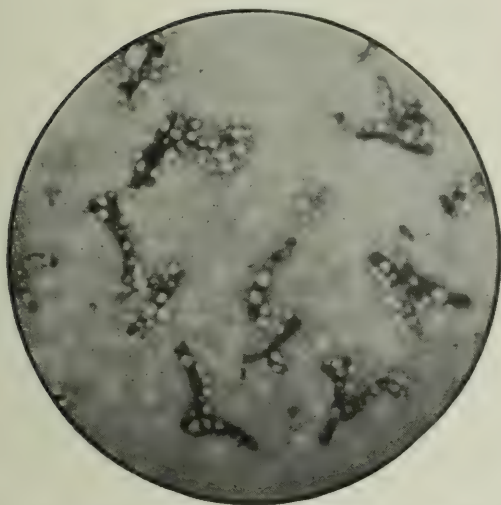
Caragana frutescens
Robinia pseudacacia
Robinia viscosa.

VICIEÆ:

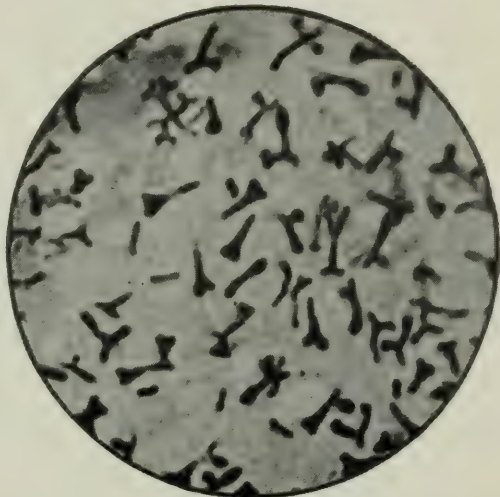
Vicia faba
Vicia americana
Lathyrus sylvestris
Lathyrus odoratus.

PHASEOLEÆ:

Phaseolus multiflorus.



7. *Ps. radicumicola* from nodule of *Melilotus officinalis*, Yellow Sweet Clover. Rods and branched forms, the latter with very irregularly distributed protoplasm. Carbol-fuchsin stain. X 1,000.



8. *Ps. radicumicola* from nodule of *Vicia villosa*, Hairy Vetch. Eosin-methylene blue stain. X 1,500.

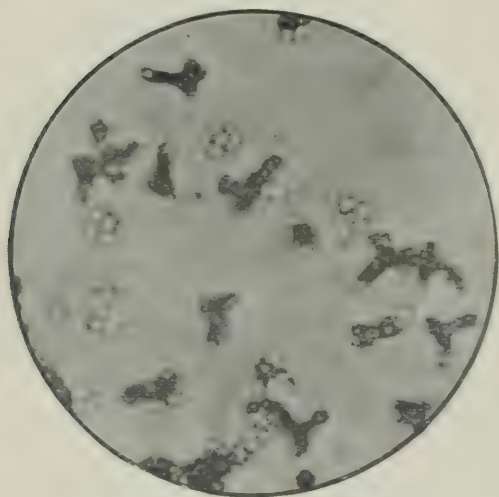
The organism was isolated, and pure cultures prepared from all but *Trifolium procumbens*. Cultures were also isolated from ten of the hosts from which cultures were previously isolated.

Investigation in media preparation was continued, and it was found that for general studies best results were obtained on media prepared in the proportion of water 100, ash .4% to 1%, maltose .4% to 1%, agar .4% to 1.5%.

Media were prepared using other substances than maltose as the source of energy for the organism. The table of modified ash-agar media, and results of growth, follow:—

Media R 129—R 146.

Stock R.	Water.	Ash.	Agar.	Sugar.	Reaction.
129.....	100	.5	1.5	.....	-7° alkaline.
130.....	"	"	"	Maltose, 1.	
131.....	"	"	"	Mannit, .5.	
132.....	"	"	"	Dextrose, 1.	
133.....	"	"	"	Levulose, 1.	
134.....	"	"	"	Dextrin, c. p. 1.	
135.....	"	"	"	Inulin, .25.	
136.....	"	"	"	Gum tragacanth, .5	
137.....	"	"	"	Amygdalin, .25.	
138.....	"	"	"	Asparagin, .25.	
145.....	"	"	"	Dextrin, com'l 1.	
146.....	"	"	"	" "	
				Glycerine, 1.	



9. *Ps. radicicola* from nodule of *Vicia Americana*, "Wild Pea," from Big Creek, B.C. Carbol-fuchsin stain. X 1,000.



10. *Ps. radicicola* from nodule of *Vicia faba*, Horse Bean. Amyl-Gram stain. X 1,500.

Plate cultures, 17 days at 25° C., in ash-water-agar modified with sugar.

Colonies none.

R. 133, levulose, 1%.

Colonies small, 1 m.m., not viscid.

R 129, Ash-water-agar alone.

Colonies small, 2 m.m.

R 136, Gum tragacanth, 1/2%, all viscid.

R 137, Asparagin, 1/4%, only 1,400 viscid.

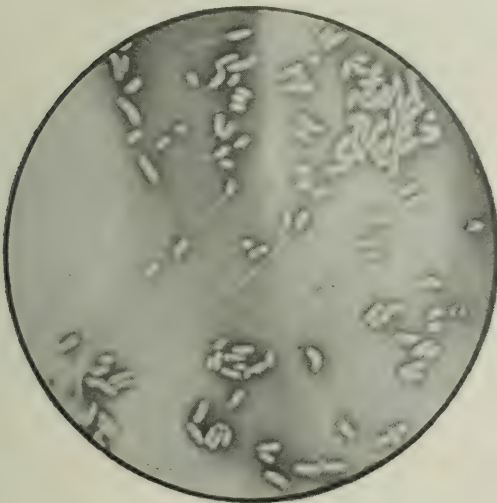
R 135, Inulin, 1/4%, only 1,300 viscid.

Colonies large, 3-10 m.m., deep 2-4 m.m., all very viscid.

R 131, 1/2% mannit	2-4 m.m. in 4 days surface colonies.
4-7 " " 7 " " "	
5-10 " " 17 " " "	
2-4 " " 17 " " "	
R 132, dextrose, 1%	6-12 " " 17 " " "
R 137, amygdalin, 1/4%...	4-10 " " 17 " " "
R 130, maltose, 1%	3 " " 17 " " "
R 134, Dextrin, 1%	3 " " 17 " " "

The cultures used in the above plate cultures were:—*Vicia villosa*, (stock culture), *Vicia villosa*, direct from nodule of host plant, *Trifolium pratense*, direct from nodule of host plant, *Trifolium pratense*, (stock culture), *Pisum sativum*, (stock culture).

Five plates were made in each of the ten media. Wherever growth occurred, it was typical of *Ps. radiculicola*, as was the morphology of the organisms in stained preparations



11. Culture of *Ps. radiculicola* from *Vicia villosa*, Hairy Vetch, on ash-maltose-agar showing flagella. Saturated alcoholic gentian violet stain. X 1,000.



12. *Ps. radiculicola* from nodule of *Trifolium pratense*, Red Clover. Amyl-Gram stain. X 1,000. Compare with No. 30.

Streak Culture on Agar, 25° C. Character of the growth was typical of *Ps. radiculicola*, the rapidity and abundance being stated as follows: Growth abundant in 10 days—Maltose, Mannit, Dextrose, Amygdalin; growth less abundant—Dextrin; growth scant—Inulin, asparagin, Gum Tragacanth, no sugar; growth none—Levulose.

Time of appearance. No colonies were visible to the eye in 48 hours. Colonies were visible to the eye in 3 days in all plates of the series except in maltose, dextrin and dextrose. In maltose and dextrin colonies were visible in 3 to 4 days; in dextrose in 7 to 9 days.

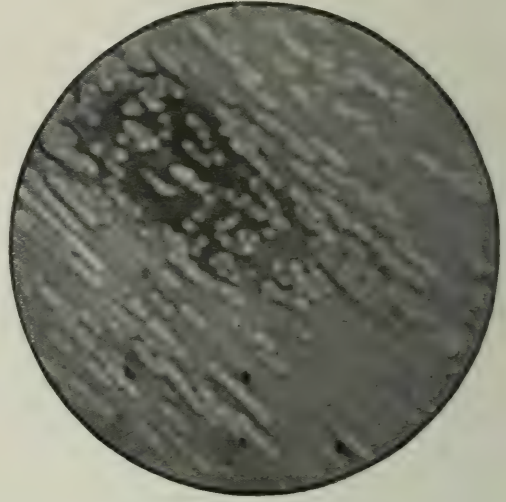
From the results it is seen that maximum growth in 17 days occurred in dextrose, mannit, and amygdalin, was very scant in asparagin and inulin, and was nil in levulose.

The effect of the different sugars in liquid media was also tried. The media consisted of ash-water, stock E 87, modified as follows:—

Stock E.	Water.	Ash.	Sugar.
87.....	100	.5	None.
87 a.....	"	"	Glycerine, .5.
87 b.....	"	"	Mannit, .5.
87 c.....	"	"	Dextrose, 1.
87 d.....	"	"	Maltose, 1.
87 e.....	"	"	Levulose, 1.
87 f.....	"	"	Raffinose, .5.



13. *Ps. radicicola* from *Trifolium pratense*, Red Clover. From colony on ash-maltose-agar, R 112. Saturated alcoholic gentian violet stain. X 2,000.



14. *Ps. radicicola* from the nodule of *Phaseolus multiflorus*, Scarlet Runner Bean. Rod forms only in nodule. Saturated alcoholic gentian violet stain. X 1,500.

The cultures used were stock cultures on ash-maltose-agar from the following host plants:—*Trifolium pratense*, red clover; *medicago sativa*, alfalfa; *Trifolium hybridum*, alsike clover; *Pisum sativum*, peas; *Vicia villosa*, vetch; *Lathyrus odoratus*, sweet pea; *Phaseolus vulgaris*, bean; *Robinia pseudacacia*, locust,

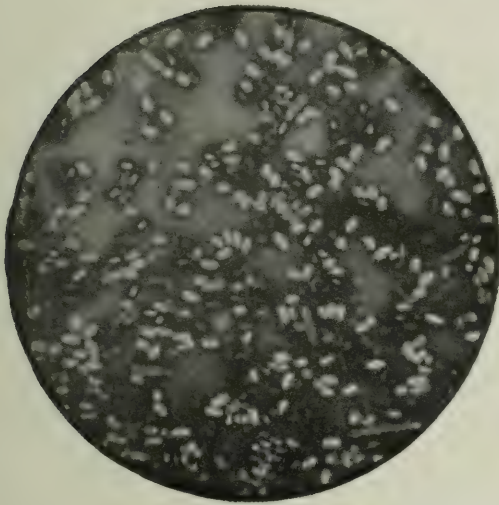
The results follow:—

Four days at 25° C.—

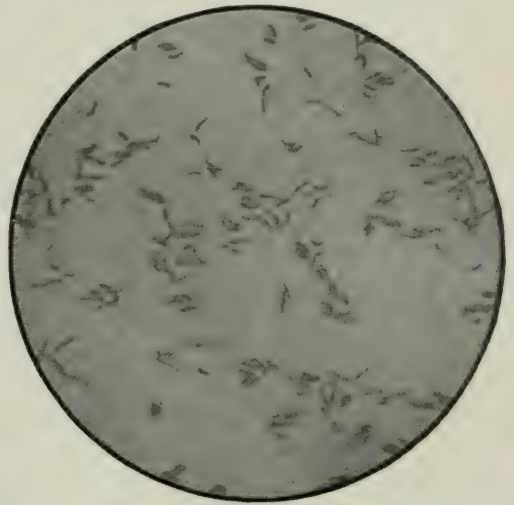
E 87 (no sugar). No growth of any cultures.

E 87 a, (glycerine). No growth—Alfalfa, red clover. Slight cloudiness—All others.

- E 87 b, (mannit). No growth—Alfalfa. Slight cloudiness—All others.
- E 87 c, (dextrose). No growth—Alfalfa, peas, locust. Slight cloudiness—All others.
- E 87 d, (maltose). No Growth—Vetch, locust. Slightly cloudy—Alfalfa. Very markedly cloudy—All others.
- E 87 e, (levulose). No growth—All cultures.
- E 87 f, (raffinose). Slightly cloudy—All cultures.
- Twenty-two days at 25° C.—
- E 87 (no sugar). Very slight cloudiness of all cultures.
- E 87 a, (glycerine). Slightly cloudy—Alfalfa, beans, alsike clover. Markedly cloudy—All other cultures.
- E 87 b, (mannit). Slightly cloudy—Alfalfa, locust. Markedly cloudy, with copious sediment—All other cultures.



15. *Ps. radiculicola* from *Phaseolus vulgaris*, Garden Bean. From colony on ash-maltose-agar. Saturated alcoholic gentian violet stain. X 1,000.



16. *Ps. radiculicola* from nodule of *Robinia pseudacacia*, Black Locust. Carbol-fuchsin stain, X 1,000.

- E 87 c, (dextrose). Slightly cloudy—Alfalfa, locust, vetch, peas. Densely cloudy—All other cultures.
- E 87 d, (maltose). No growth—Locust. All other cultures very densely cloudy with copious sediment, and pellicle in some cases.
- E 87 e, (levulose). No growth in any cultures.
- E 87 f, (raffinose). Slightly cloudy—Alfalfa, locust, beans, peas, Markedly cloudy—All others.

The results show that of the sugars tried maltose gave the most abundant growth in liquid media. The unsuitability of levulose in media for *Ps. radiculicola* was shown as in the solid media tests, there being no growth in any cultures.

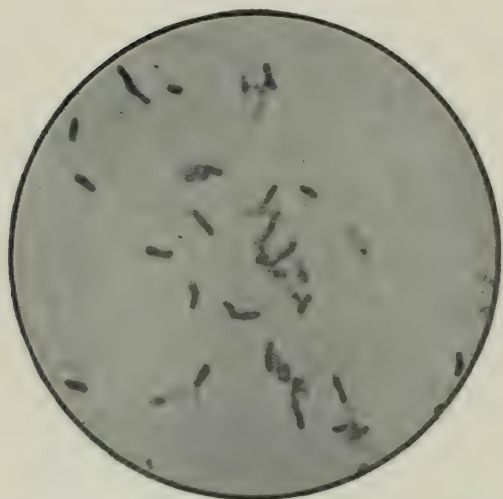
ISOLATION OF *Ps. radicicola* FROM THE NODULE.

The technique of isolation from the nodule was varied slightly from the method used in the previous studies, the exact procedure being as follows:—

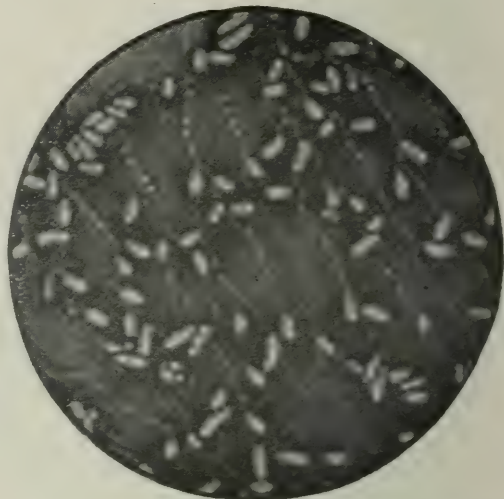
The plant is dug, care being observed not to break off the nodules, and the roots placed immediately in clean, cool water. Parts of the plant are preserved for identification, and nodules removed to killing and fixing solutions preparatory to sectioning.

A nodule is removed from the roots, washed thoroughly under the tap and immersed in 50 c.cm. to 100 c.cm. of the following solution:—

Hydrochloric acid, sp. gr. 1.20	2.5 c.cm.
Mercuric chloride crystals	1 g.
Water, distilled or tap	1,000 c.cm.



17. *Ps. radicicola* from nodule of *Glycine hispida*, Soy Bean. Mostly small rod forms. Carbol-fuchsin stain. X 1,500.



18. *Ps. radicicola* from *Lathyrus odoratus*, Sweet Pea. 25 day old culture on ash-maltose-agar. Saturated alcoholic gentian violet stain. X 1,500.

The nodules may remain immersed for 2-3 minutes unless in the case of large nodules, as from soy beans, when a longer immersion does no harm. The nodule is taken with flamed forceps and placed between folds of filter paper moistened with the above solution. The nodule is held with flamed and cooled forceps and broken open with a flamed platinum knife or small scalpel. A flamed needle is thrust into the middle of the broken surface, gently rotated, and then touched into a drop of sterile water in a sterile Petri dish. Three loopfuls of this inoculated water are transferred to a second drop of sterile water in the same dish. A third drop in the same dish is inoculated from the second in like manner. In a second Petri dish, three drops of sterile water are inoculated in the same succession, the first transfer being from drop 3 in the first dish. Liquified ash-maltose-agar, cooled to near its solidifying temperature,

is mixed with the several drops of inoculated water, and the plates when solidified may be placed at a temperature of 20° or 25° C.

At the same time at least three smears should be made from the nodule for staining.

Hanging drop examinations are also made, crushing a particle of the bacteroidal tissue in a drop of distilled water on a cover glass.

Studies of the cultural and morphological characteristics were continued, and the observations previously noted were confirmed. Figs. 1 to 30.

In a few plants, notably *Pisum sativum*, when the nodule was broken open the bacteroidal tissue was observed to be mucilaginous. Hanging drop preparations showed some large branched cells, non-motile, and some small or minute rods swiftly and actively motile, darting, whirling, and tumbling. Some of the mucilaginous tissue, spread on a slide and stained with saturated alcoholic gentian violet, gave a typical flagella stain, showing the cells and whips unstained in the densely stained background.



19. *Ps. radicicola* from *Medicago sativa*, Alfalfa. Colony on ash-maltose-agar. X 200.



20. *Ps. radicicola* from *Lathyrus odoratus*, Sweet Pea. Colony on ash-maltose-agar. X 100.

VIABILITY OF *Ps. radicicola*.

Observations on the viability of *Ps. radicicola* on ash-maltose media have been continued. It would appear that on favourable media the organism is long lived. The results obtained in this laboratory are embodied in the following table. The cultures were grown a short time at 20° or 25° C., and were then kept at the temperature of the laboratory. These same cultures were all successfully transferred to various other media more than once in the interval recorded in the table, and gave a prompt and characteristic growth on favourable media. The transfers in the table were to ash-maltose-agar in all cases, and to

ash-maltose-water in some cases. The growth, morphology, and staining reactions were carefully observed, and were characteristic of *Ps. radicicola*. The same is true of colonies which developed in plate cultures in ash-maltose-agar made from certain of these cultures, after a lapse of nearly three and one-half years in one case. The growth was abundant and mucilaginous, the cells were actively motile in hanging drops, and stained with saturated alcoholic gentian violet they showed single polar flagella. Occasional branched forms were seen from agar cultures and were frequent in liquid media.

Viability of Ps. Radicicola in Cultures at Room Temperature.

Data March, 1908.

Isolated from.	Stock number.	Cultivated in water 100% with				Alive after	
		Ash.	Maltose.	K H ₂ P O ₄ .	Agar.	Years.	Days.
Scarlet Runner Bean (<i>Phaseolus multiflorus</i>)	R 107	%	%	%	%		
	R 107	0.5	1	0	1	1	137
	R 107	0.5	1	0	1	1	235
Bean (<i>Phaseolus vulgaris</i>)	R 35	1	2	0	1	3	146
	R 35	1	2	0	1	3	140
	R 35	1	2	0	1	1	253
	R 35	1	2	0	1	1	259
Red Clover (<i>Trifolium pratense</i>)	R 112	0.2	0.5	0	1.5	1	27
	R 112	0.2	0.5	0	1.5	1	125
	R 72*	1	1	0	0.9	1	301
	R 72	1	1	0	0.9	1	91
Sweet Pea (<i>Lathyrus odoratus</i>)	R 105	0.5	1	0	1	1	148
	R 105	0.5	1	0	1	1	246
Alfalfa (<i>Medicago sativa</i>)	R 54	0.5	1	0	0	3	43
	R 54	0.5	1	0	0	1	146
	R 54	0.5	1	0	0	1	156
	R 34	1	0**	0	1	1	340
	R 54	0.5	1	0	0	1	123
Soja Bean (<i>Glycine hispida</i>)	R 106	0.5	0.6	0.03	0	1	221
Horse Bean (<i>Vicia faba</i>)	R 107	0.5	1	0	1	1	117
	R 107	0.5	1	0	1	1	209
	R 104	1	1	0	1	1	210
Hairy Vetch (<i>Vicia villosa</i>)	R 54	0.5	1	0	0	3	43
	R 44*	1	2	0	1	1	353
White Clover (<i>Trifolium repens</i>)	R 36	1	1	0.5	1	1	181
Peas (<i>Pisum sativum</i>)	R 104	1	1	0	1	1	244
	R 87	1	1	0	1	1	343
	R 87	1	1	0	1	1	341
	R 36	1	1	0.5	1	1	175
	R 36	1	1	0.5	1	2	26

Data March, 1908.—*Continued.*

Isolated from	Stock number.	Cultivated in water 100% with				Alive after	
		Ash.	Maltose.	K H ₂ P O ₄	Agar.	Years.	Days.
Bitter Vetch (<i>Lathyrus sativus</i>)	R 118	0.2	0.5	0	1.5	0	356
	R 112	0.2	0.5	0	1.5	1	125
	R 112	0.2	0.5	0	1.5	1	27
	R 35	1	2	0	1	2	159
	R 35	1	2	0	1	1	335
Black Locust (<i>Robinia pseudacacia</i>) . . .	R 105	0.5	1	0	1	1	198
	R 105	0.5	1	0	1	1	296
Flat Pea (<i>Lathyrus sylvestris</i>)	R 104	1	1	0	1	1	243
	R 104	1	1	0	1	1	335
Wild Bean (<i>Apios tuberosa</i>)	R 36	1	1	0.5	1	2	47
Tick trefoil (<i>Desmodium nudiflorum</i>) . . .	R 79	1	1	0	0	1	274
Siberian Pea Tree (<i>Caragana frutescens</i>)	E 31	1	0.5	0	1	2	126
Red Clover (<i>Trifolium pratense</i>)	R 104	1	1	0	1	2	139
	E 30***	1	0.5	0.5	1	1	347
Soy Bean (<i>Glycine hispida</i>)	E 30	1	0.5	0.5	1	1	358
Sweet Pea (<i>Lathyrus odoratus</i>)	E 31	1	0.5	0	1	2	37
Garden Pea (<i>Pisum sativum</i>)	E 30	1	0.5	0.5	1	2	104
Alsike Clover (<i>Trifolium hybridum</i>)	R 104	1	1	0	1	2	139
Bitter Vetch (<i>Lathyrus sativus</i>)	E 30	1	0.5	0.5	1	2	125
Flat Pea (<i>Lathyrus sylvestris</i>)	E 30	1	0.5	0.5	1	2	125
Alfalfa (<i>Medicago sativa</i>)	E 30	1	0.5	0.5	1	2	35
Black Medick (<i>Medicago lupulina</i>)	E 30	1	0.5	0.5	1	2	125
Horse Bean (<i>Vicia faba</i>)	E 30	1	0.5	0.5	1	2	15
Black Locust (<i>Robinia pseudacacia</i>) . . .	E 30	1	0.5	0.5	1	1	358
Honey Locust (<i>Robinia viscosa</i>)	E 30	1	0.5	0.5	1	2	121
Dutch White Clover (<i>Trifolium repens</i>)	E 31	1	0.5	0	1	2	98
"Wild Pea" (<i>Vicia Americana</i>)	E 86†	0.4	0.5	0	1	0	121
Garden Bean (<i>Phaseolus vulgaris</i>)	E 31	1	0.5	0	1	2	117
Scarlet Runner Bean (<i>Phaseolus multi-</i> <i>florus</i>)	E 32	0.2	0.5	0	1.5	1	220
Hairy Vetch (<i>Vicia villosa</i>)	R 104	1	1	0	1	2	133
Sweet White Clover (<i>Melilotus alba</i>) . . .	E 30	1	0.5	0.5	1	2	123

* Cultures made from this culture were distributed for inoculation of seed in 1906

** Sucrose 2%.

*** Isolated from dried plants from Medicine Hat, Alta.

† Plants from Big Creek, B.C.

The studies on viability in cultures of ash-sugar-agar will be continued. For the purpose it is desirable to have receptacles for the cultures, holding an ample quantity of medium, and so constructed as to reduce the rate of evaporation to a minimum. Two forms of such flasks, designed in this laboratory, made of Jena glass, are shown in Figs. 39

and 40. Determinations showed that in the smaller flask, half filled, 40 to 50 years would elapse before evaporation of the agar was complete.

EFFECT OF DESICCATION.

Limited studies were made on the effect upon *Ps. radicicola* of desiccation on seed, on glass, and on filter paper.

Desiccation on Seeds. A culture was taken from the stock as prepared and ready to send to farmers for seed inoculation, was shaken with sterile water, 600 c.cm., until the agar was thoroughly broken up.

Dilutions were made in sterile water, and ash-maltose-agar plates poured to determine the number of organisms in the culture.

Portions of seed purchased in the local seed stores were handled as follows :—

Portion A.—One pound seed inoculated with 10 c.cm. of stock culture as diluted above.

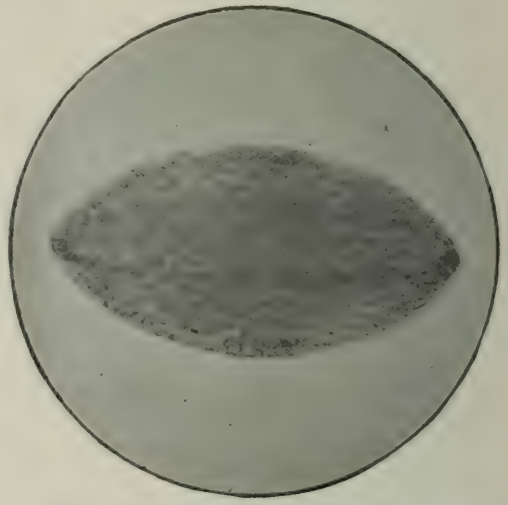
Portion B.—One pound seed uninoculated.

Portion C.—One pound *sterilized* seed inoculated with 10 c.cm. of stock culture diluted as above.

Portion D.—One pound *sterilized* seed uninoculated.



21. *Ps. radicicola* from *Vicia faba*, Horse Bean. Colony on ash-maltose-agar. X 100.



22. *Ps. radicicola* from *Vicia villosa*, Hairy Vetch. Colony on ash-maltose-agar. X. 200.

Some inoculated seeds were immediately plated in ash-maltose-agar, and the remainder were dried in folds of sterile cotton and cheese cloth at room temperature and stored in sterile deep Petri dishes. For subsequent platings, seeds were placed in sterile Petri dishes in about a c.cm. of sterile distilled water, and allowed to remain thus fifteen to twenty minutes, the seeds being moved about occasionally with sterile forceps, the plates being then poured with ash-maltose-agar of the same stock in every case as was used for the first plating.

In this manner, desiccation on beans, peas, and red clover seed was observed, the results appearing in the table following:—

Number of Bacteria Alive on Seeds After Varying Periods of Drying.

PEAS.

		Before drying.	After 2 days,	After 6 days.	After 13 days.	After 228 days.
Seed + Culture	1	4,045	38	28	6	0
	2	6,487	59	21	28	0
	3	26,711	12,364	20	17	0
	4	9,799	636	152	14	0
Seed	1	382	.....	54	14	0
	2	191	.....	47	21	1
	3	719	.....	63	32	0
	4	954	.....	87	19	2
Sterile seed + Culture	1	41,594	604	65	0	0
	2	6,754	446	18	0	0
	3	2,823	259	34	0	0
	4	14,639	708	103	0	0
Sterile seed	1	0	0	0	0	0
	2	2	1	2	0	0
	3	0	0	0	0	0
	4	0	0	0	1	0

BEANS.

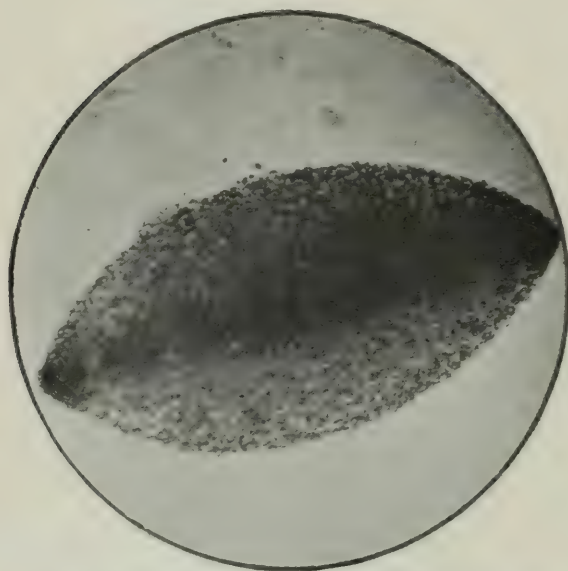
RED CLOVER.

Before drying.	After 24 hrs.	After 6 days.	After 14 days.	After 223 days.	Before drying.	After 24 hrs.	After 6 days.	After 216 days.
7,085	5,787	2,989	1,372	0	477	53	50	0
37,333	.....	.....	5,215	mass on seed	21,636	40	43	0
14,437	13,582	3,243	2,874	0	.....	39	200	0
31,066	31,036	2,035	1,963	0	381	59	49	0
35	.....	21	.....	3 + mass on seed	69	.....	0	0
56	.....	15	.....	1	3	.....	0	0
41	.....	.....	.....	3	18	.....	0	0
28	.....	.....	.....	3	8	.....	0	0
29,065	0	.....	0	.....	.....	.....	.....	.....
27,602	0	.....	0	.....	.....	.....	.....	.....
34,782	0	.....	0	.....	.....	.....	.....	.....
26,056	0	.....	0	.....	.....	.....	.....	.....
0	0	.....	0	.....	.....	.....	.....	.....
0	0	.....	0	.....	.....	.....	.....	.....
0	0	.....	0	.....	.....	.....	.....	.....
0	0	.....	0	.....	.....	.....	.....	.....

A duplicate series of determinations were made with closely similar results.

Desiccation on Glass. From the same dilution of culture in each case as was used for inoculating seed sterile cover slips, one-half inch circles, received a two m.m. loop of the culture suspension. Some slips were plated in ash-maltose-agar immediately; the remainder were placed in sterile Petri dishes and were allowed to dry spontaneously at room temperature. For plating, the slips were removed to another sterile Petri dish with sterile forceps, flooded with sterile water, and after 15 to 20 minutes the plates were poured with ash-maltose-agar.

In every case the plate cultures of cover slips plated immediately on spreading showed more than 200 colonies—in some cases several thousand. In no case, however, did any colonies develop in plate cultures made 24 hours after the covers first received the culture.



23. *Ps. radicola* from *Phaseolus vulgaris*, Garden Bean. Colony 12 days old on ash-maltose-agar. X 200.



24. *Ps. radicola* from *Phaseolus vulgaris*, Garden Bean. Group of colonies on ash-maltose-agar. X 200.

Desiccation on Paper. Pieces of filter paper of uniform size and shape were soaked in the suspension of culture prepared for inoculating seed; some pieces were plated immediately in ash-maltose-agar, the remainder being distributed in sterile Petri dishes and allowed to dry spontaneously at room temperature. For subsequent platings the pieces were flooded with sterile water a few minutes before pouring the plates, the pieces being moved about at intervals with sterile forceps. Colony counts showed that not more than 0.03% of the bacteria survived for 24 hours after being placed on the papers.

A sample of sweet pea seed supposed to be inoculated with a commercial culture of the appropriate organism for this species of plant

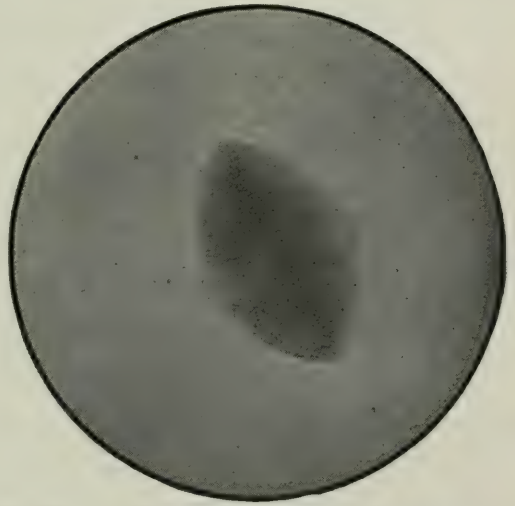
was examined, and of eight seeds placed in ash-maltose-agar only one colony in one of the eight plates showed a characteristic staining reaction and cultural characters for *Ps. radicicola*.

The results obtained are in accord with the observations of other investigators that *Ps. radicicola* is especially susceptible to desiccation under these conditions.

A few observations were made upon the viability of *Ps. radicicola* in the dried nodule. It has always been our practice to preserve portions of plants and roots at the time of isolation of cultures, using the ordinary botanical plant presses. In plating from these dried specimens, the nodules were removed, washed in mercuric chloride solution, 1-1,000, and placed in sterile water until the nodule was plump. The ordinary procedure for plating, as heretofore described, was then followed. In every case, when growth occurred, the colonies were typical, as were also the staining reactions.



25. *Ps. radicicola* from *Lathyrus sylvestris*, Flat Pea. Colony 17 days on ash-maltose-agar. X 100.



26. *Ps. radicicola* from *Robinia pseudacacia*, Black Locust Colony 22 days on ash-maltose-agar. X 100.

The results of these observations follow:—

Viability of Ps. radicicola in Dried Nodules.

Host Plant.	Bacteria alive after		Relative number of colonies.
	Years.	Days.	
Vicia Faba.....	0	137	Very many.
Vicia Faba.....	2	33	Few.
Medicago sativa.....	0	66	Very many.
Medicago sativa.....	0	93	Very many.
Glycine hispida.....	0	98	Many.
Caragana frutescens.....	2	131	Few.
Caragana frutescens.....	2	159	Few.
Trifolium pratense.....	2	138	Few.
Trifolium pratense.....	2	166	Few.

From these results, it would seem possible that a few individuals are able to withstand desiccation under this condition for long periods of time.

PREPARATION AND DISTRIBUTION OF CULTURES FOR INOCULATING SEED.

The preparation and distribution to farmers of cultures for inoculating seed was begun in the spring of 1905, and has been continued each season since. These cultures are sent in two-ounce square glass bottles, known in the trade as French squares, on ash-maltose-agar, prepared in the proportion of water 100, agar 1, maltose 0.5, ash 0.5. The bottles are filled about half full of the medium, plugged with cotton wool, sterilized, and allowed to solidify in an inclined position. Inoculation on the inclined agar surface is made from pure laboratory cultures. Growth is rapid at 25° C., and fairly abundant at 20° C. After a few days a copious mucilaginous or slimy growth covers the surface of the agar and gravitates to the bottom of the incline. In this condition the culture contains an ample number of bacteria to inoculate sixty pounds of seed. Plate culture determinations have shown that the ordinary cultures, when ready for distribution, contain from ten million to more than five billion living bacteria.

Before sending the culture the cotton stopper is replaced by a flamed cork, a sheet of directions is wrapped round the bottle and enclosed in a paper mailing case. See Fig. 45.

A copy of the directions sent with cultures follows:—

DIRECTIONS FOR INOCULATING SEED WITH NITROGEN-GATHERING BACTERIA.*

Each legume requires a different culture.

This bottle contains bacteria sufficient for inoculating sixty pounds
of.....seed.

All the culture may be used on less seed without harm.

The culture is good for the season of 19.....

This culture is sent you with the understanding that you will use it as directed and report to us the result of your experiment. Follow directions carefully or failure may result.

1. Cover the seed with water and let it soak two hours.
2. Drain off the water. This may be done by heaping the seed on a cloth on the ground, or Nos. 1 and 2 may be done in a grain bag.

* Hereafter these directions will be modified to avoid the "sticky" seed caused by application of the sugar.

3. Mix one pound of dry granulated sugar with each bushel of the wet seed, and let the seed stand thus over night.

4. Next day pour a little clean cold water into the bottle of culture, shake until the jelly is well broken up, pour it over the seed and mix *thoroughly*.

5. Plant at once, just as you would uninoculated seed. If the seed is too wet and sticks together, spread it out in a shady place for about ten minutes. It should be neither wet nor dry, but as moist as it can be handled. In case of a mixture of clover with other seed, it is advisable to treat the clover separately, mixing just before sowing.

6. Do not open the bottle until you are ready to treat the seed, and do not treat more seed at one time than can be sown in a day.

7. At least a small plot should be planted with untreated seed for comparison, and this should be planted first.

8. Send us in the empty bottle with your name and address, a small sample of the inoculated seed for further laboratory tests.

9. After the seedlings are one month old, search for nodules, "little bunches," on the roots. Examine for nodules again after three months. During the season note number and size of nodules and vigor of plant growth from treated and untreated seed.

The price of each culture is twenty-five cents.

Originally the farmer was directed to shake the culture up thoroughly with a pint of water, mix the liquid with the seed and sow at once. It was found, however, during the last year that if the seed was soaked a few hours, and sugar added, the moisture on the seed was conserved, and the deleterious effect of desiccation of the bacteria before the seed was sown was largely overcome. That large numbers of the bacteria actually did enter the soil in the living condition is shown by the following :

EXAMINATION OF SEED SAMPLES RETURNED.

As noted in the directions, a request was made that recipients of the cultures the season just past send us, in the empty culture bottles, a small sample of the inoculated seed.

As soon as the sample was received, two average seeds were selected from the sample, placed in sterile Petri dishes, flooded with sterile water, allowed to stand 15 or 20 minutes, and the plates poured with ash-maltose-agar. The plates were incubated at room temperature, counts being made on the tenth day. At the time of making the count smears were made and stained with saturated alcoholic gentian violet. When only comparatively few colonies were present, these smears were made from single colonies. Where the colonies were very numerous, the smears were made by drawing the sterile loop through or over the surface of the medium.

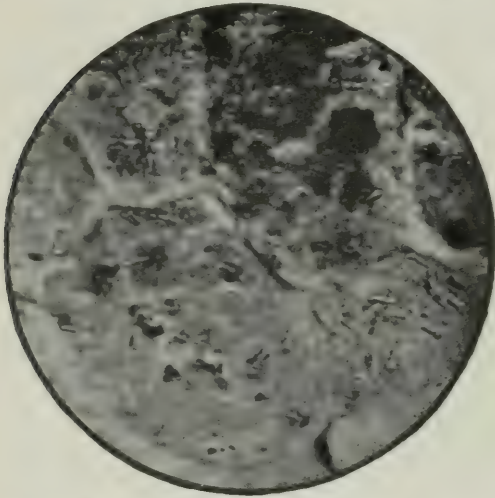
In all, there were plated two seeds from each of 227 samples of different seeds, the number of samples of each kind being as follows: Alfalfa, 152; red clover, 52; alsike clover, 11; field peas, 7; sweet peas, 5.

In all but 25 of the 454 plates, stains with saturated alcoholic gentian violet showed typical reactions for *Ps. radicicola* and in 55 plates flagella were demonstrated.

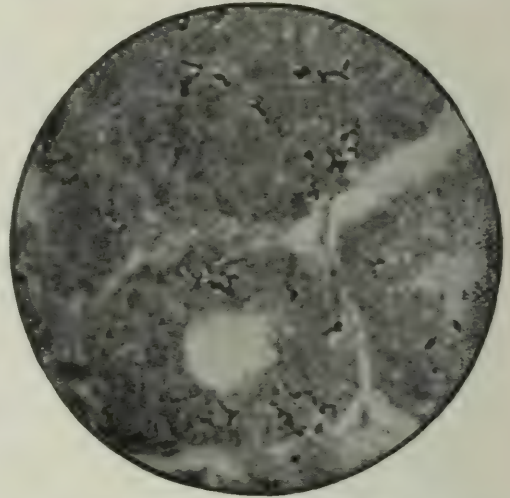
The number of bacteria per seed, as indicated by the colony counts, is shown in the following table:—

Number bacteria per seed.	Samples.	Per cent.
None or stain negative.....	25	5.56
Less than fifty.....	91	20.04
Between 50 and 500.....	71	15.63
500 to 10,000.....	115	23.12
10,000 to 20,000.....	47	10.35
20,000 to 40,000.....	57	12.33
Over 40,000.....	36	8.14
Too numerous to count.....	12	2.64

From these results it would appear that a very ample number of bacteria go into the ground with the seed and in a vigorous condition.



27. *Ps. radicicola* in section of nodule from *Vicia villosa*, Hairy Vetch. Fixed in chrome-acetic acid and stained with Anilin-safranin-gentian violet. X 1,000.



28. *Ps. radicicola*. Section of nodule from *Vicia villosa*, Hairy Vetch, prepared as in 27. X 1,000.

This method of distributing cultures to farmers offers several advantages over the method of distribution by commercial houses. In most, at least, of the latter, the culture contains comparatively few of the organisms required, being accompanied with the appropriate chemical salts for making up a nutrient culture medium. In the hands of the farmer, the culture is certain to become contaminated, with the result that the *Ps. radicicola* may be inhibited or even entirely destroyed by the growth of foreign organisms. In the method followed in this laboratory, the bacteriologist assumes the responsibility for preparation

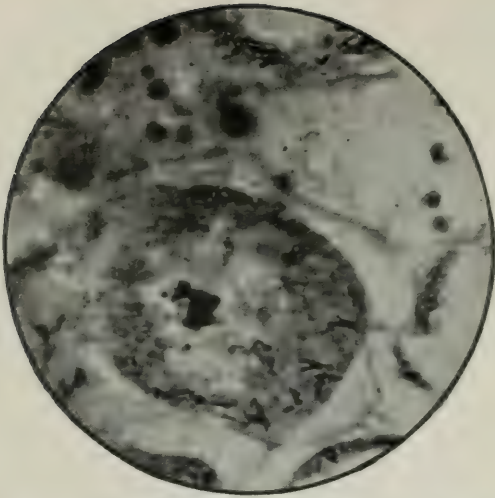
of the nutrient medium, and the propagation of the culture, and all the farmer has to do is to apply the bacteria to the seed.

We give herewith a brief resumé of results from the use of cultures for the past four seasons, as shown by farmers' reports. During 1905, 246 cultures were sent out, 134 reports being returned.

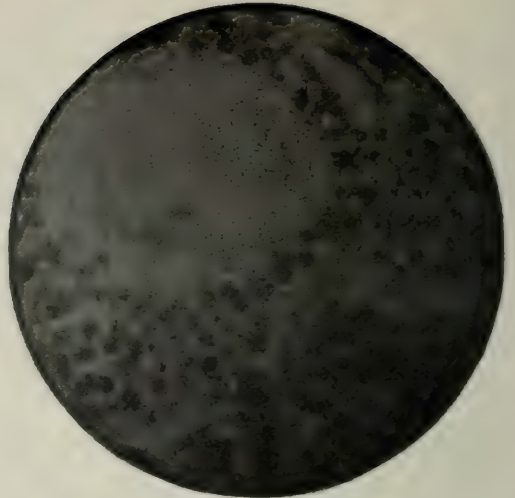
Crop.	Total No. of reports received.	Inoculation successful, with increased growth of crop.	Organisms already present in the soil.	No advantage from inocu- lation.
Lucerne or alfalfa	59	43	1	15
Red Clover	47	31	1	15
Peas	12	7	1	4
Beans	9	5	.....	4
Alsike Clover	2	1	.....	1
White Clover	1	1	.....	.....
Vetch	3	2	.....	1
Soy Bean	1	1	.....	.....
	134	91	3	40

During 1906, 375 cultures were distributed; 120 reports were returned, 72 showing a benefit to the crop and 48 of no apparent benefit.

Province.	Crop Grown.	Result.		
		Benefit.	No Benefit.	
Ontario.....	Alfalfa.....	12..	9	3
	Red Clover.....	14..	10	4
	Peas.....	14 .	9	5
	Beans.....	11..	6	5
	Soy Beans.....	3..	2	1
	Alsike.....	1..	1	.....
	Vetch.....	1..	1	.....
	Sweet Pea.....	1..	1	.....
Alberta.....	Alfalfa.....	13..	6	7
	Red Clover.....	3..	1	2
	Peas.....	1..	1	.....
Saskatchewan	Alfalfa.....	1..	.....	1
	Red Clover.....	2..	.....	2
	Peas.....	1..	1	.....
	Beans.....	1..	.....	1
	Vetch.....	1..	.....	1
Manitoba	Alfalfa.....	2..	2	.....
	Red Clover.....	8..	6	2
Quebec.....	Alfalfa.....	3..	3	.....
	Red Clover.....	1..	1	.....
	Alsike.....	1..	1	.....
United States.....	Alfalfa.....	5..	3	2
	Red Clover.....	4..	1	3
	Peas.....	3..	2	1
	Beans.....	2..	1	1
	Soy Beans.....	6..	1	5
	White Clover.....	2..	2	.....
	Vetch.....	1..	.....	1
New Brunswick	Red Clover.....	2..	1	1



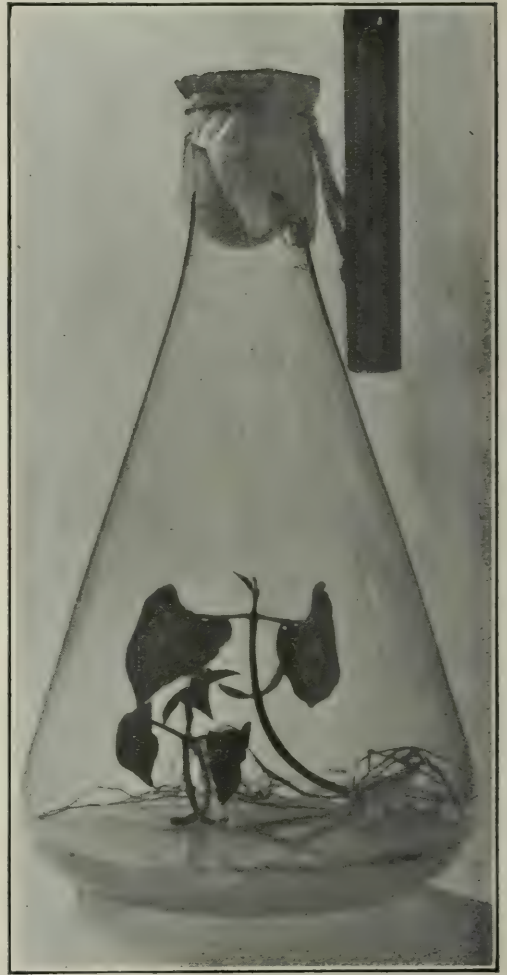
29. *Ps. radiicola*. Section of nodule from *Trifolium pratense*, Red Clover. Stained as in 27. X 1,000.



30. *Ps. radicicola*. Section of nodule from *Trifolium pratense*, Red Clover. Stained as in 27. X 1,000. Compare with No. 12.



31. *Lathyrus odoratus*, Sweet Pea, showing the method of germinating sterile seeds under sterile conditions. These seedlings are ready to transplant into flasks.



32. *Phaseolus vulgaris*, Garden Bean, growing on ash-maltose-agar in 1½ L. Erlenmeyer flask.

During the season of 1907, there were distributed 372 cultures, and reports were available from 124. The summary of these is shown:—

Province.	Alfalfa.		Red Clover.		Alsike Clover.		Peas.		Beans.		Sweet Pea.	
	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.	Benefit.	No Benefit.
Ontario.....	36	28	6	11	2	....	2	2	1	....	....	....
New Brunswick.....	2	....	1	....	....	....	....	....	....	....	....	....
Saskatchewan.....	1	2	....	....	....	....	....	....	....	....	....	....
Alberta.....	1	1	....	....	....	....	....	....	....	....	....	....
P. E. Island.....	2	....	....	....	....	....	....	....	....	....	....	....
British Columbia.....	1	2	....	2	....	....	....	....	....	....	1	1
Quebec.....	3	1	....	....	....	....	....	....	....	1	1	....
Manitoba.....	1	1	....	1	....	....	....	1	....	....	....	....
Nova Scotia.....	1	....	2	....	....	1	....	....	2	....	....	....
Indiana, U.S.A.....	....	1	....	....	....	....	....	....	....	....	....	....
England.....	....	....	....	1	....	....	....	....	....	....	....	....
Ohio, U.S.A.....	....	....	....	....	1	....	....	....	....	....	....	....
Total.....	48	36	9	15	3	1	2	3	3	1	2	1

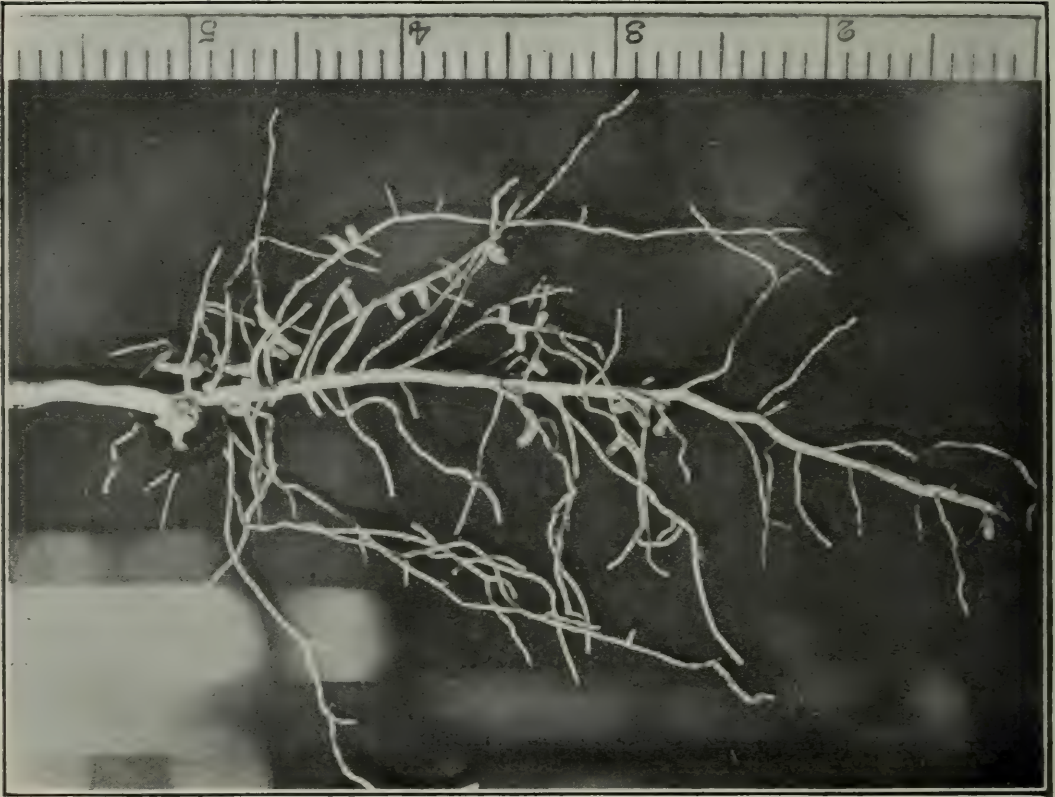
Total showing beneficial results, 54%.

Total showing no apparent benefit, 46%.

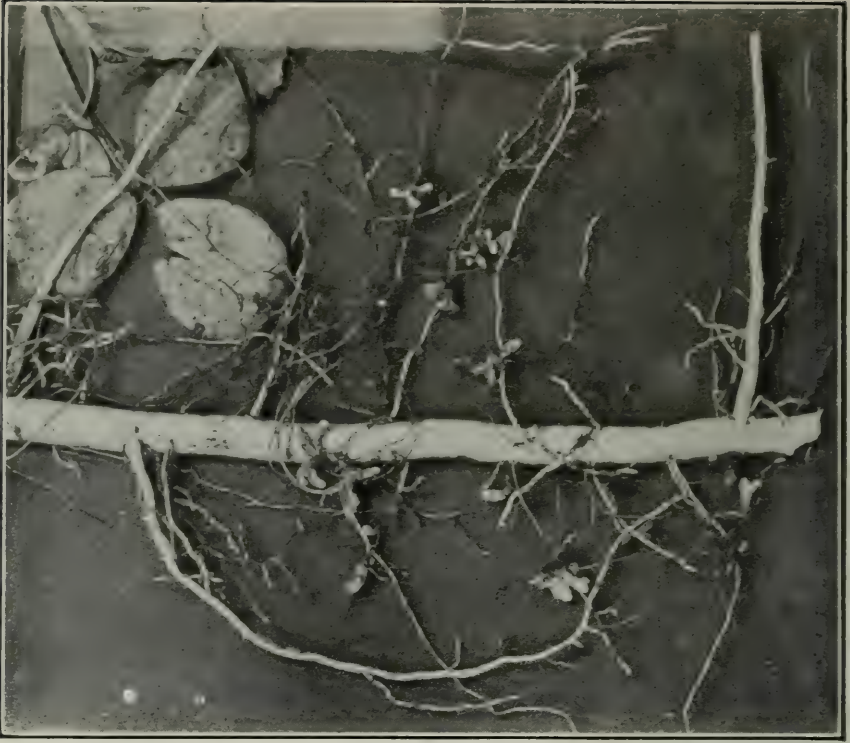
The distribution of cultures was continued during the season just passed, and a total of 2,113 cultures was sent, as noted in the table:—

Province.	Alfalfa.	Red Clover.	Beans.	Alsike Clover.	Peas.	Sweet Peas.	Vetches.
Ontario.....	1,236	319	31	68	108	17	4
Quebec.....	49	9	....	2	....	1	....
Nova Scotia.....	17	9	2	3	8	....	1
New Brunswick.....	12	3	....	....	1	....	....
P. E. Island.....	11	5	....	2	1	....	....
Newfoundland.....	1	....	....	....	....	....	....
Manitoba.....	16	3	....	1	....	....	....
Saskatchewan.....	11	1	....	1	2	....	....
Alberta.....	35	2	1	....	9	....	....
British Columbia.....	39	11	3	7	2	2	....
United States.....	3	12	....	2	7	3	....
England.....	2	....	....	....	1	....	....
Mexico.....	2	2	....	2	1	....	1
Sweden.....	....	1	....	....	1	....	1
Total.....	1,434	377	37	88	141	23	7

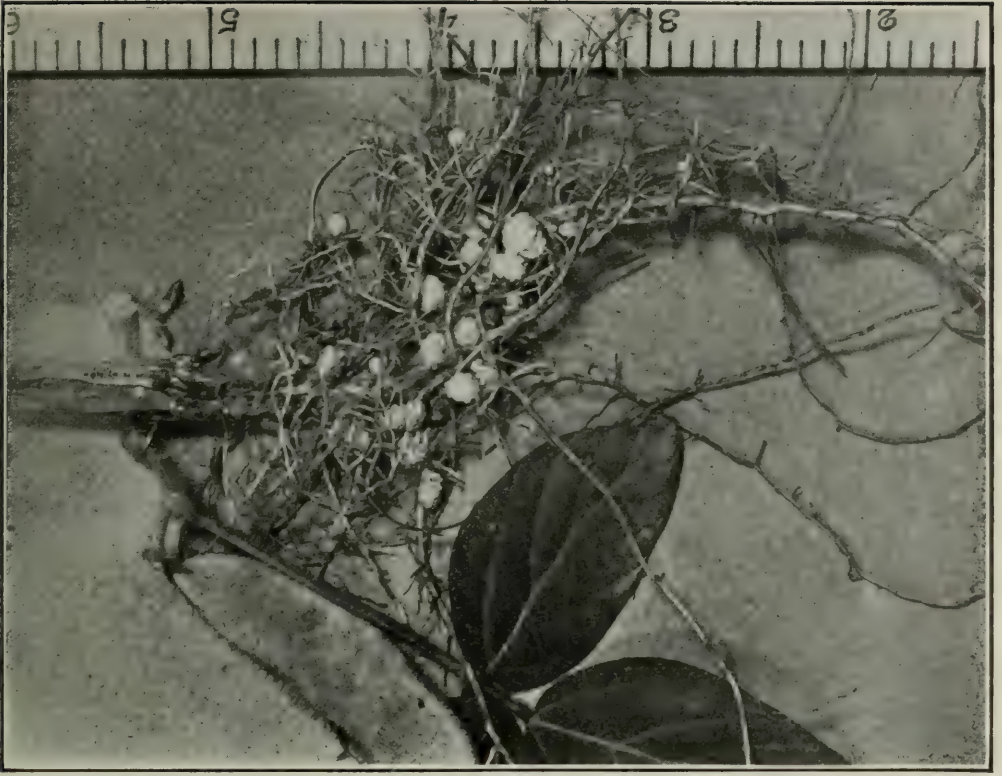
Also two cultures for yellow trefoil, and four for sweet white clover were sent.



33. Root of *Lathyrus odoratus*, Sweet Pea, showing nodules.



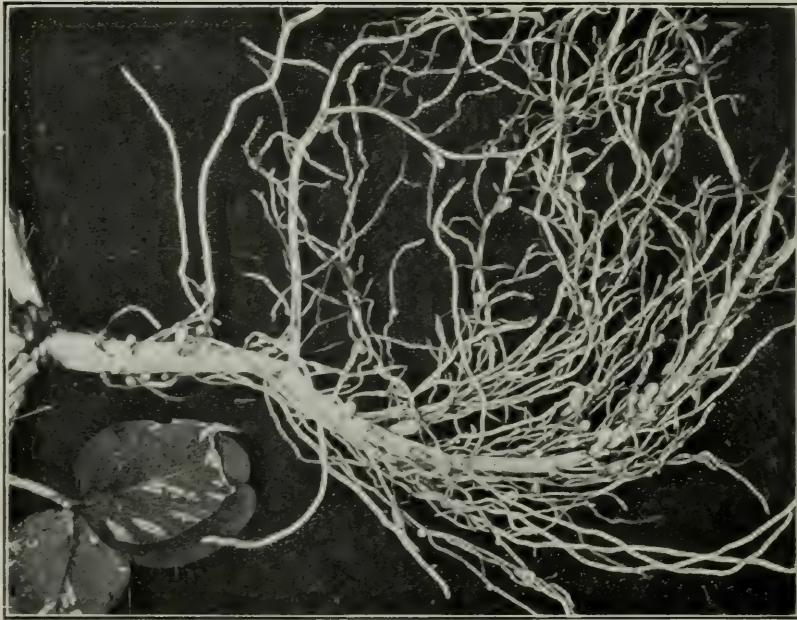
34. Portion of root of *Medicago sativa*, Alfalfa, showing nodules. Natural size.



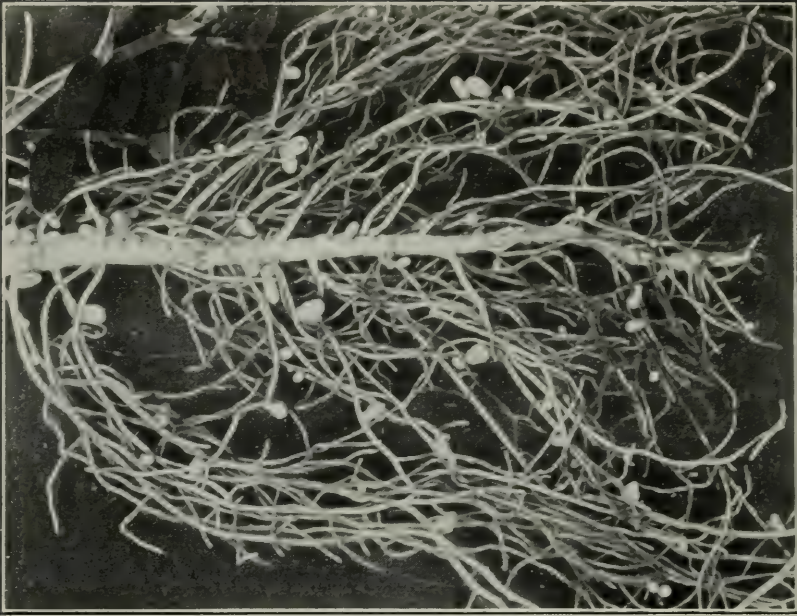
36. Root of *Glycine hispida*, Soy Bean, showing nodules.



35. Root of *Pisum sativum*, Garden Pea, showing nodules.



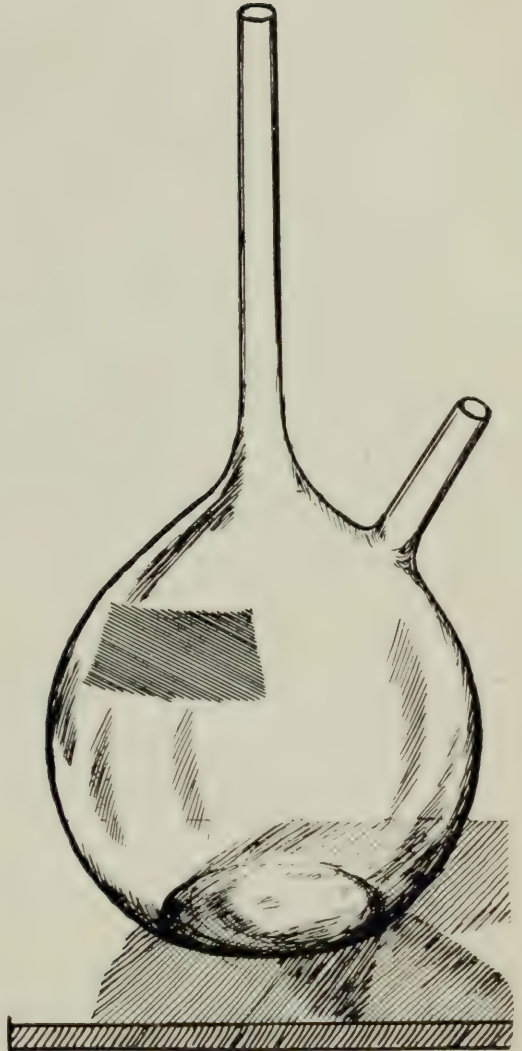
37. Root of *Trifolium pratense*, Red Clover, showing nodules.
Natural size.



38. Root of *Vicia villosa*, Hairy Vetch, showing nodules.
Natural size.



39. Viability flask of Jena glass.
Capacity about 50 c. cm.



40. Viability flask of Jena glass. Capacity about 100 c. cm. The long neck may be sealed after growth is abundant. When it is desired to transplant, the tube may be cut off, and resealed in the flame. There is ample length to repeat this several times if necessary.

The results of the season's inoculation, as seen from a summary of reports received, are shown in the table. The plus columns indicate the number of reports in which the farmer stated a positive beneficial result from the inoculation. The minus columns include all others. In many cases, the crop experimented with had been grown on the same ground previously, and the soil was probably already inoculated. Two farmers thought the inoculation was harmful to the crop.

Results of Seed Inoculation, 1908.

	Alfalfa.		Red Clover.		Alsike Clover		Peas.		Beans.		Sweet Peas.	
	+	—	+	—	+	—	+	—	+	—	+	—
Ontario....	261 65 %	140 35 %	43 50.5 %	42 49.5 %	9	5	9	16	4	4	2	1
B. Columbia	11 78.5 %	3 21.5 %	5 83.3 %	1 16.7 %							1	
Alberta....	10 55.5 %	8 44.5 %	1 100 %				2					
Quebec....	10 62.5 %	6 37.5 %									1	
P. E. Island	4 80 %	1 20 %	1 100 %									
Sask.....	3 75 %	1 25 %					1					
Nova Scotia	4 57+ %	3 43— %	2 67.7 %	1 33.3 %	1		1	1			1	
New Bruns.	3 75 %	1 25 %	1 100 %									
Manitoba..	3 60 %	2 40 %	2 100 %									
U. S. A....				1 100 %			1					
Total....	309 65 %	165 35 %	55 55 %	45 45 %	10 66.7 %	5 33.3 %	14 44 %	17 55 %	4 50 %	4 50 %	5 83.3 %	1 16.7 %

Following is the form of blank report sent to recipients of cultures :

DEAR SIR,—

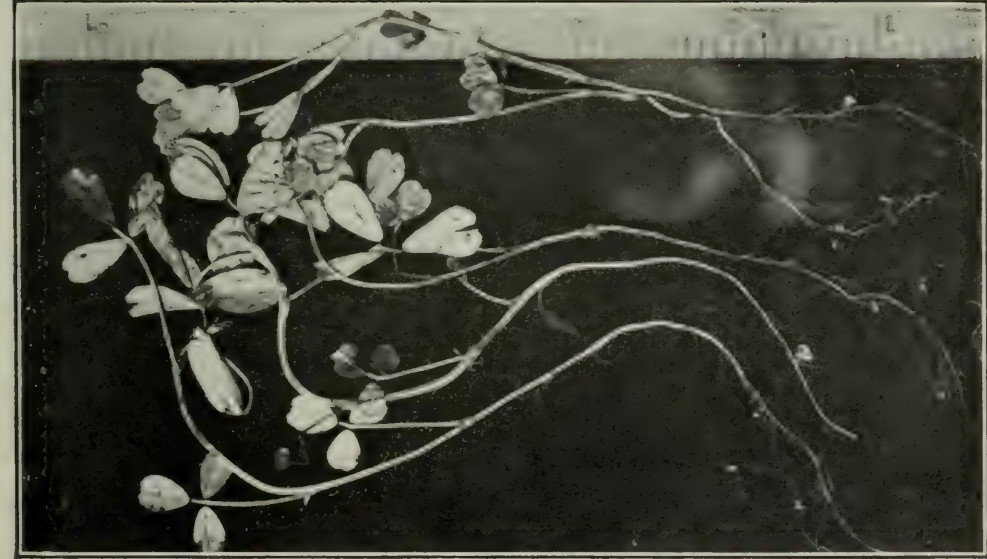
Below is a blank for reporting the results of your experiment with nodule forming bacteria for legumes. We will esteem it a favour if you will fill out this report and return it to us promptly in the enclosed envelope.

Crop seeded
 Character of land
 Amount of treated seed.....
 Amount of untreated seed

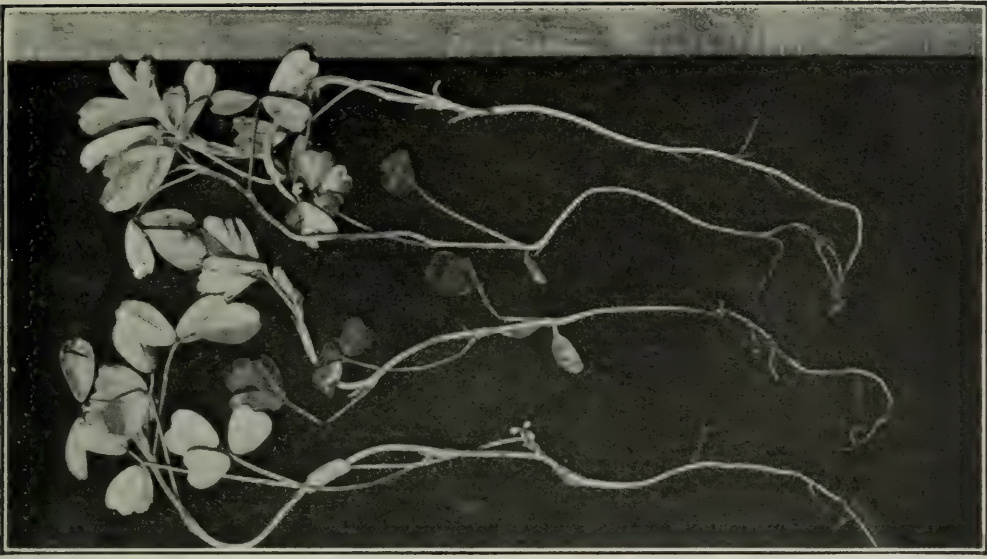
	With Culture.	Without Culture.
Area of land planted.....		
Nodules present or absent at one month.....		
Few or numerous nodules after three months ..		
Vigor of plants after three months.....		

Do you think your crop has been benefited by the culture?.....
 Do you expect to use similar cultures next season?.....
 Weather conditions during the season?.....
 Remarks:—

Your name
 Post Office
 Province.....



41. Alfalfa plants one month old, from inoculated seed. Berlin, Ont.



42. Alfalfa plants one month old from uninoculated seed sown in the same field and at the same time as No. 41. Berlin, Ont.



43. Average plants from inoculated and uninoculated portions respectively of a field of alfalfa. Ontario Agricultural College.



44. Alfalfa plants from inoculated and uninoculated seed. Pictou Landing, Nova Scotia.

To briefly summarize:—A total of 2,113 cultures were distributed and reports were returned from 634, or 31.7%. Of these, positive beneficial results were stated in 397, or 62.6%, and no benefit was apparent in 237, or 37.4%.

In reply to the query, 337, or 53%, experimenters expressed a desire to secure similar cultures next season, this number including many who reported no apparent benefit this season.



45. The cultures for inoculating seed are sent out on ash-maltose-agar in 2 oz. French squares, enclosed with directions for use, in a paper mailing case.

It is the intention of the Department of Bacteriology to distribute these cultures during 1909. As heretofore, a price of 25 cents is affixed for each bottle of culture sufficient for 60 pounds or less of seed, and each farmer is expected to submit a report of his work at the end of the season.

LABORATORY OF BACTERIOLOGY,
GUELPH, December, 1908.

B 170

BULLETIN 170.]

[MARCH, 1909.

Ontario Department of Agriculture.

DAIRY BRANCH

MITCHELL-WALKER TEST BOTTLE

A NEW FORM OF BABCOCK TEST BOTTLE.

By J. W. MITCHELL, B. A., Supt. Eastern Dairy School, and W. O. WALKER, M.A. Lecturer on Organic Chemistry, School of Mining, and Dairy Chemistry, Eastern Dairy School.

Whether used for butter or cheese making, or for sundry other purposes that might be mentioned, milk is valuable not simply in proportion to its weight, but rather in proportion to the one or more solids which it contains and which we wish to utilize. For butter-making it is valuable in proportion to the amount of butter-fat which it contains, and for cheese-making practically in proportion to its fat and casein content.

The need of a thoroughly practical test for determining the per cent. of fat in milk was a want that was long felt before it was actually realized, and it led many to study the subject with a view to satisfying this want. The farmer needed it to aid him in the building up of his dairy herd, it was needed in creameries in order that an equitable division of the proceeds might be made, and it was realized that such a test would be most valuable for testing the by-products with a view to preventing undue losses through these channels; and we would add that such a test should be in general use in cheese factories, in connection with the division of the proceeds, instead of the "pooling" system or the system of dividing the proceeds merely in accordance with the weight of milk, which latter method is all but universal at the present time.

On this continent and in different countries outside of it the Babcock test has, for good and substantial reasons, supplanted all of its rivals for the determining of fat in milk and its products and by-products. It is simple, speedy, and accurate; and as but a single, cheap

reagent is used the cost of a test is small. It is already used in nearly all of our creameries for the purpose of estimating the value of milk and cream for butter-making purposes and dividing the proceeds amongst the several patrons accordingly; and, as has already been intimated, it should, with the requisite modifications, be generally adopted for a like purpose in our cheese factories.

The extra time and labor it entails is undoubtedly one of the chief factors that have militated against the general introduction of the test into cheese factories, although this reason is not usually brought very prominently to the fore by advocates of the "pooling" system. We venture to say, however, that few if any dairymen of prominence will say that the "pooling" system is a just one.

It is but fair, then, to conclude that any improvement that can be made in the test, in the way of lessening the time and labor involved in conducting it, will be much appreciated by all factorymen now using it and will greatly help to popularize the test and hasten its more general introduction.

There were some features of the test, as heretofore applied, which we looked upon as demanding more time and care than was desirable, and these objectionable features we felt might be eliminated by some modification in the apparatus and conducting of the test.

During the present year we have done considerable experimental work with a view of shortening the length of time required for conducting the test. Our main point of attack has been upon that part of the test which involves the stopping of the centrifugal machine during the test, adding hot water to the individual bottles and again whirling the bottles before the readings are taken.

We started our work on the principle of the use of a small centrifuge to be placed on the spindle of the ordinary centrifuge for the purpose of receiving and conveying the water to the bottles while the machine was in motion. This necessitated a modification of the test bottle for the purpose of receiving the water from the small centrifuge. After much experimental work we have succeeded in devising a centrifuge and bottle that give every satisfaction.

THE WATER CENTRIFUGE.

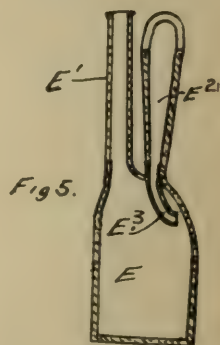
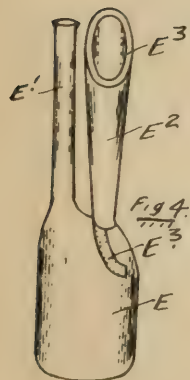
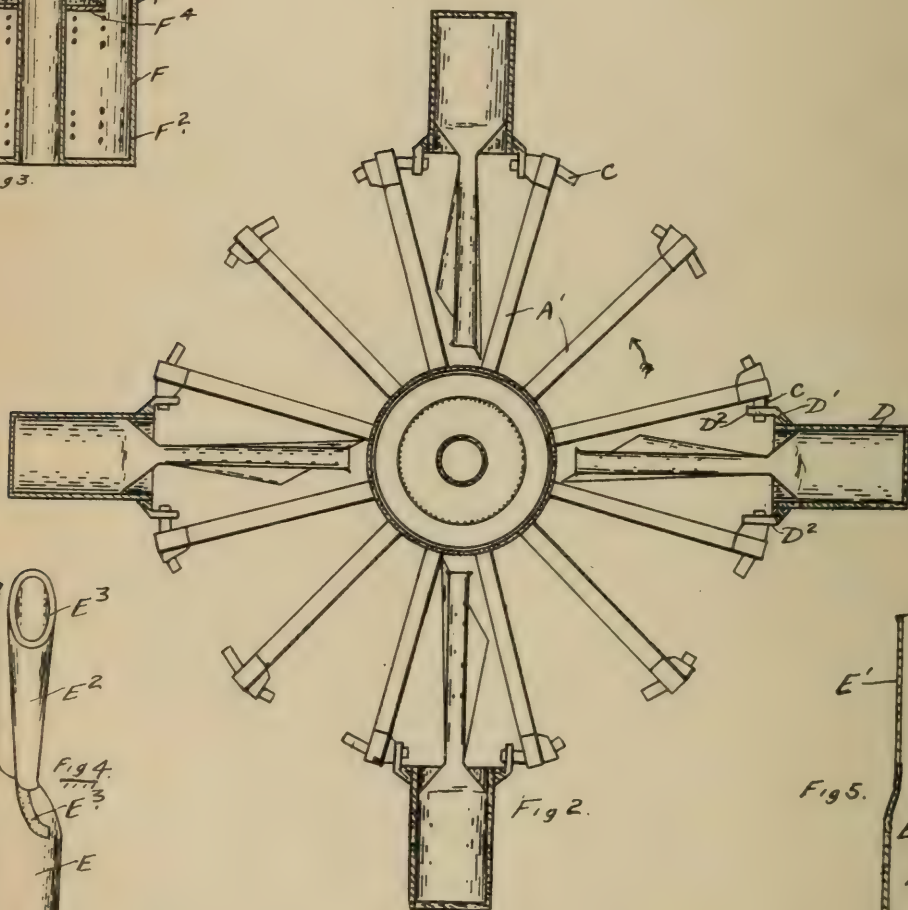
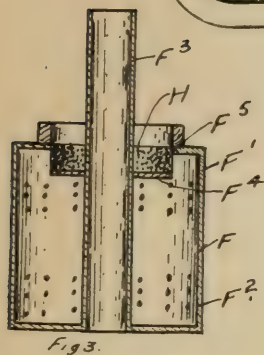
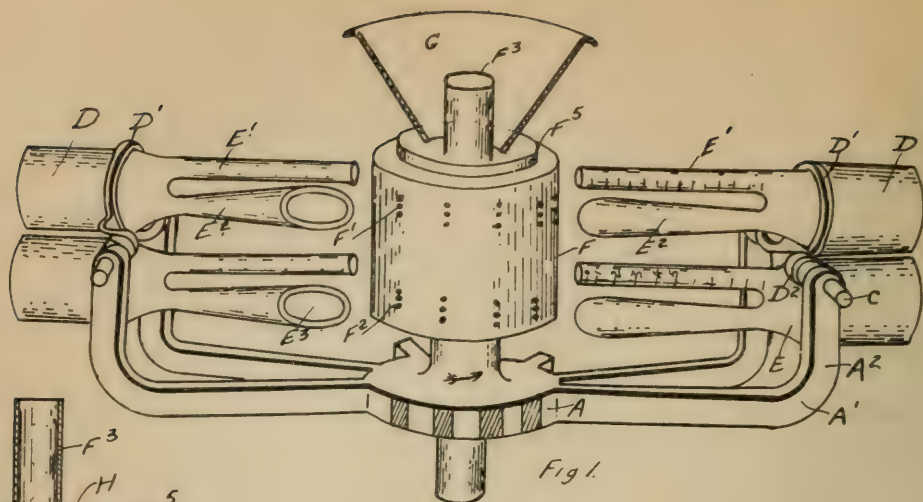
The small centrifuge that is placed on the spindle of the machine, for the purpose of adding water to the bottles while in motion, is what we mean by the term *water centrifuge*, there being, in addition, the large centrifuge for whirling the bottles. The first forms of centrifuge designed by us were made on the principle of a hollow cylinder perforated for the exit of the water. It had a horizontal plate with wings on its upper side, the purpose of these being to set the water in motion and prevent its falling to the bottom of the centrifuge to too great an extent, as it was necessary to direct it in two main streams, upper and

lower, to fill two rows of bottles in the machine. We have discarded the wings entirely so that now the centrifuge is perfectly simple in construction, consisting simply of a hollow cylinder with the upper and lower parts of the wall perforated. In order to guard against any particles of dirt, that might be in the water used, entering the centrifuge and stopping up the perforations we converted the above-mentioned horizontal plate into a strainer consisting of a solid bottom with sides of wire gauze that can be easily removed and cleaned when necessary. The whole centrifuge slips on to the spindle of the ordinary machine and the water is simply poured in at the top through the cone-shaped cover of the machine.

By reference to the accompanying cut the construction of the centrifuge will be readily understood.

THE BOTTLE.

The bowl and graduated neck of the bottle are similar to those of the ordinary test bottle. In addition our bottle possesses a second neck of a funnel or inverted cone shape for receiving the water from the water centrifuge on the spindle. The upper end of this neck is bevelled for the two-fold purpose of catching the water from the centrifuge and preventing the fat in the graduated neck from overflowing. The lower end of the neck is reduced in size and prolonged into a curved tube for the purpose of preventing any fat from rising into it during the test. Furthermore, the direction in which it curves, namely, toward the outer wall of the bottle, causes the acid to flow down the side of the bottle to the bottom, thus avoiding its mixing with and charring the sample.



DESCRIPTION OF THE CUI.

Fig. 1 is a perspective view of our improved apparatus partially broken away and in section.

Fig. 2 is a sectional plan showing portion of the cups and bottles, the bottles being shown in full.

Fig. 3 is a detail of the water centrifuge.

Fig. 4 is a perspective detail of the bottle.

Fig. 5 is a longitudinal section through the bottle and necks thereof.

In the drawings like letters of reference indicate corresponding parts in each figure.

A is a spider which is journalled on a shaft B, and comprises arms A^1 bent at the outer end and A^2 substantially at right angles to the main portion of the arm. C are trunnions secured in the end of the arm and D are a pair of cylindrical cups which are provided with a connecting rim D^1 having the centrally opposed lugs D^2 , which are journalled on the trunnions C.

E are the bottles which are placed in the cups D. Each bottle is provided with a graduated neck E^1 and a substantially funnel or cone-shaped neck E^2 having a bevelled outer end E^3 . The position in which the cups and bottles are shown in the drawing is that which they assume when the machine is in motion. When the machine is stationary the cups and bottles stand upright.

F is the water centrifuge, which comprises a cylinder having upper and lower sets of perforations F^1 and F^2 in its periphery, each set of perforations being substantially of the same width as the outer end of the funnel-shaped neck E^2 of the bottle E. As will be readily seen there are two layers of bottles, which assume the horizontal position when the machine is in motion and consequently the upper and lower necks E^2 are directly opposite the upper and lower sets of perforation F^1 and F^2 respectively.

F^3 is the centre tube of the cylinder, which is secured on the shaft B. F^4 is a deflecting plate horizontally disposed beneath the top of the centrifuge F and opposite the flanged opening F^5 , into which a funnel G is fitted in order to feed the water into the centrifuge.

H is a strainer of wire gauze or netting extending from the flange F^5 to the deflecting plate F^4 , such wire gauze being designed to prevent dust or foreign matter passing into the centrifuge and stopping the jets F^1 or F^2 . Both the centrifuge and the spider carrying the bottles are secured to the shaft and rotate in unison. As the machine revolves, the water in the centrifuge is forced by the centrifugal action outward in the form of a spray and is caught by the cone-shaped necks of the bottles circularly arranged as will be readily understood.

The inner ends of the funnel or cone-shaped necks of each bottle are extended in somewhat the form of a curve E^3 at its entrance into the bottle for the purpose previously mentioned.

ADVANTAGES OF THE BOTTLE AND CENTRIFUGE.

1. The milk and acid can be readily added to the bottle through the wide mouth of the funnel-shaped neck.
2. The acid flows down the side of the bowl without charring the sample.
3. *The water can be added to the bottles while the machine is in motion, thus saving much time.*
4. Two rows of bottles can be used.
5. The bottles may be emptied very rapidly—twenty-four in less than one minute.
6. Water can be added to the bottles very quickly for cleaning them after the test, either while at rest or in motion.
7. No special form of machine is required. We have been using the bottles and centrifuge with well-known makes of machines.
8. The funnel-shaped neck on the skim-milk bottle eliminates the danger of spurting out of the acid when shaking the contents, on account of the lower opening being above the surface of the liquids, thus allowing the gases to escape freely.
9. The foregoing may be summed up by saying that there is a saving of time from beginning to end of the test.

DIRECTIONS FOR USING THE BOTTLE AND CENTRIFUGE.

1. Add the milk and acid through the funnel-shaped neck. Shake the contents as usual.
 2. Place the small water centrifuge on the spindle with the perforations just behind the arms of the large centrifuge and at the right height to fill the bottles.
 3. Place the bottles in the pockets of the machine with the funnel-shaped necks on the inside or toward the spindle.
 4. Have the cover of the machine fitting closely.
 5. After whirling the bottles from four to five minutes pour the water through the cover of the machine at a rate corresponding to that of a stream from a half inch pipe. Use from two to three quarts of water or enough to ensure the filling of the bottles.
 6. Continue whirling the bottles from one to two minutes after all the water is added.
 7. See that the speed is maintained during the addition of the water.
 8. When emptying the bottles have the graduated neck underneath.
 9. The general principles and precautions that govern the conduction of a test with the ordinary bottle are assumed to be understood by the operator and expected to be applied when using the new bottle.
- For particulars regarding price, etc., write to W. O. Walker, Eastern Dairy School, Kingston, Ontario.

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE

Insects Affecting Vegetables.

By C. J. S. BETHUNE.

Before taking up in order the insects that attack the various plants grown in our vegetable gardens, attention may be drawn to a number of kinds that are general feeders, not limiting themselves to any particular varieties, but attacking almost everything that comes in their way ; on that account they are the most serious foes that we have to contend against and in many cases the most difficult to keep under control.

APHIDS (Plant-lice)—Figs. 1 and 2—are minute pear-shaped, soft-bodied insects that may be found on almost every kind of plant, usually in dense colonies clustered thickly on the terminal twigs and buds, on the under-side of leaves, on stems and other parts, and even under ground on roots. Wherever situated they are occupied in the same manner—sucking out the life-juices of the plant and multiplying their own numbers by constant reproduction of living young all through the summer. There are a great variety of species, most of them varying shades of green in color, some are shining black, others bright red ; some again are covered with waxy filaments resembling threads of cotton wool, and others with a dusting of a mealy substance composed of the same material. Singly they are insignificant creatures, but occurring as they do in enormous numbers and multiplying with amazing rapidity, they are able to seriously injure and often to destroy the vegetation that they attack. Fortunately they are devoured by many predaceous insects, such as lady-bird beetles and their larvae and those of lace-winged and syrphus flies and other creatures (Figs. 3 to 8); washed off and drowned by heavy rains, and reduced in

NOTE.—The object of this Bulletin is to furnish the vegetable grower, whether on the farm or in the garden, with a convenient manual for the identification of the ordinary insect and fungus pests which injure his crops, and to describe the remedies which experience has proved to be the most effective in each case. As a general rule it will be found that thorough tillage of the soil, a short rotation of crops, ample manuring and clean cultivation are the best of all remedies. All refuse remaining on the ground after the crop has been removed, such as stalks, roots and leaves, should be got rid of by burning or burying in order to leave no shelter for wintering insects and no diseased material for the spread of fungus diseases. Weeds of all descriptions, especially in fence corners and waste places, should be cut down before going to seed, or plowed under from time to time ; they harbor many of our worst pests in summer and winter, and often afford convenient breeding places for enemies which the vegetable grower is endeavoring to combat on his cultivated plants.

numbers by internal parasites ; otherwise they would in time destroy all vegetable life. Ants are usually to be found prowling about the colonies ; they do not eat the Aphids, as might be suspected, but are attracted by the sweet "honey-dew" that exudes from them, and take them under their special protection.



Fig. 1. Winged aphid and wingless form—much magnified.



Fig. 2. Wingless aphid—greatly enlarged.

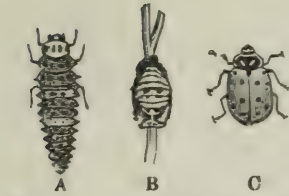


Fig. 3. Lady-bird beetle—
A, larva; B, pupa; C, beetle
—natural size.



Fig. 4. Lady-bird beetle and
larva—magnified.



Fig. 5. Lady-bird
beetle—slightly
enlarged.



Fig. 6. Lace-winged fly.

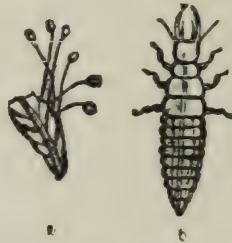


Fig. 7. Lace-winged fly—
A, eggs on stems; B, larva.



Fig. 8. Syrphus-fly
larva sucking an
aphid.

In gardening operations nature's checks are not sufficient, but require to be supplemented with artificial remedies such as kerosene emulsion, strong washes of soap-suds or tobacco decoction. In greenhouses they can be kept in control by burning the commercial preparation of tobacco.

ANTS. These insects are often suspected of injuring the plants over which they are seen running, but as a rule they are only indirectly responsible. A few species, such as the large black Carpenter Ants, form their galleries in trunks of trees, posts and timber and do a considerable amount of damage, but the great variety of smaller species which infest our gardens do not feed upon foliage or injure growing plants. Sometimes they may be found upon unopened flower buds, but they are only attracted by some sweet secretions on the surface; as a rule their presence indicates that there is a colony of Aphids near by, which they take under their protection in order to obtain from them the sweet "honey-dew" exuded by these minute creatures. The worst injury for which ants are responsible is the establishment of colonies of Aphids upon the roots of many plants; the ants collect the eggs and take care of them during the winter and when growth is sufficiently advanced carry them to the roots and look after them during the summer, in order to have a constant supply of "honey dew." These colonies increase rapidly and soon check the growth of the plant and ultimately destroy it. Where ants' nests abound, frequent digging and stirring of the soil, and in field cultivation repeated disking and harrowing, will get rid of many, or they may be treated with carbon bisulphide; a small quantity should be poured into the entrance of the nest or into a hole made with a stick and quickly covered with earth; the fumes will speedily kill all the inmates. It is best to perform the operation towards evening when all the ants are within the nest. This is a very effective mode of getting rid of the large colonies which make mounds of rubbish on lawns and in fields.

CUTWORMS. At the beginning of the growing season the gardener often finds in the morning young plants cut off near the surface of the ground that the evening before were strong and healthy. On stirring up the soil near by he may find hidden in the ground a greasy-looking caterpillar, the culprit in the case. Cutworms, so called from this habit, are the caterpillars of dull-coloured night-flying moths (Figs. 9, 10 and 11) of a great variety of species and varying to some extent in their habits. As a general rule they are partly grown at the approach of winter and hide away in a torpid state during the cold weather; when restored to activity by the warmth of spring, which causes the buds to open and the growth of plants to begin, these worms come out in search of food and attack any kind of tender vegetation that they meet with. They are nocturnal in their habits and hide away during the hours of daylight under any shelter they can obtain or just below the surface in the loose soil of newly made beds. Owing to their destructive practice of cutting off a whole plant in order to devour a portion of its foliage, they do a great deal of apparently needless damage.

After they have become fully grown they change to the chrysalis stage in the ground and in early summer the moths appear, many of them making their presence known in our houses by their attraction

to light. Before very long another brood of caterpillars comes upon the scene, often more numerous and more destructive than the first. Some of them climb up into fruit trees and destroy the foliage, others

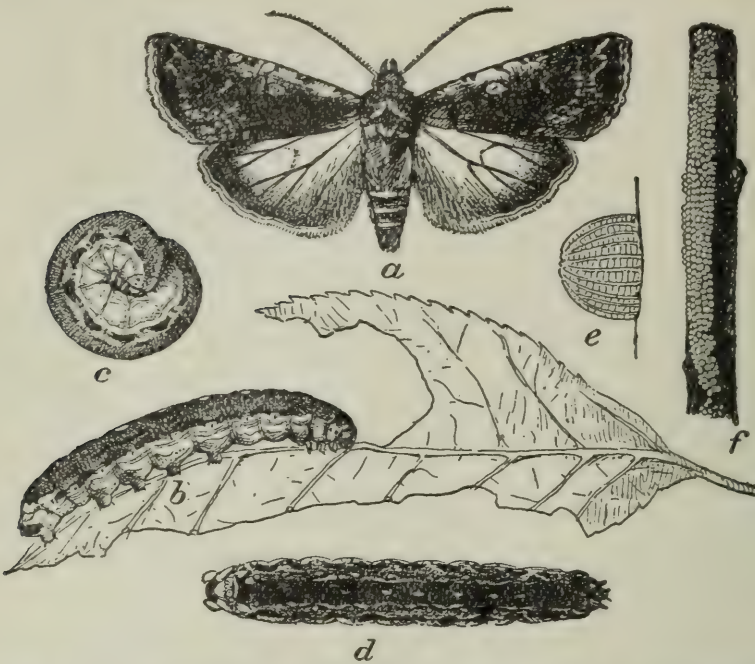


Fig. 9. Variegated Cutworm—*a*, moth ; *b*, *c*, *d*, caterpillars ; *e*, egg (magnified); *f*, eggs on a stem.



Fig. 10. Cutworm and Moth.

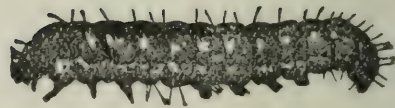


Fig. 11. The Glassy Cutworm.

attack farm crops, vegetables, grape vines, the plants in flower gardens, etc., while occasionally a single species appears suddenly in enormous numbers and sweeps like an army over the land devouring everything that comes in its way.

Happily a very simple and completely effective remedy has been found for these destructive creatures. It is called the "poisoned bran-mash" and is made in the following manner: Mix half a pound of Paris green in 50 lbs. of bran (the proportion for larger or smaller quantities is 1 to 100); the poison should be added to the dry bran little by little and stirred all the time till the whole is tinged with the green colour, then add water sweetened with sugar, or molasses, till the mixture is sufficiently moistened to crumble nicely through the fingers. If bran cannot be procured, shorts or flour may be used, and for field work may be distributed dry by means of a seed drill. The mash should be scattered about the plants that are liable to attack in the evening, and



Fig. 12. Flea-beetle, showing dilated thigh of hind legs, and larva much enlarged.

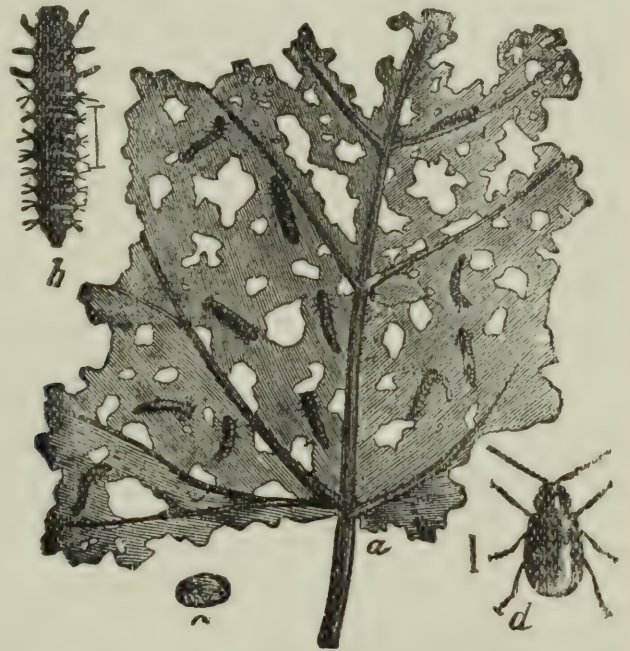


Fig. 13. Flea-beetle—*a*, leaf, with larvæ at work upon it; *b*, larva, greatly enlarged; *c*, pupa; *d*, beetle magnified.

strange to say the worms will devour it in preference to their ordinary vegetable food. When they begin to feel the effects of the poison they wander off to find a hiding place or burrow in the ground and there die. Their dead bodies will be readily found in the morning just below the surface of the ground, often in surprising numbers. Young plants, such as cauliflowers, tomatoes, &c., may be protected when set out by wrapping a bit of newspaper around the stem between the root and the leaves and reaching a little below the surface of the ground. The worms will not attempt to bite through or climb over it.

FLEA-BEETLES. There are several species of these minute insects which attack a large variety of plants; some confine their attentions to one or two kinds, while others are general feeders. The beetles are about one-tenth of an inch in length, oval and convex in form, usually

shiny black or bronzed in color, sometimes ornamented with broad, pale stripes along the back; they all possess enormously developed thighs on the hind legs (Fig. 12), by means of which they are enabled to jump with great agility and hence have acquired the name of Flea-beetles. They appear in early spring, often in large numbers, and eat small holes in the foliage of young plants (Fig. 13), preferably the thick seed-leaves. The larvæ, as far as known, feed for the most part on the roots of weeds, as well as upon some garden vegetables; clean cultivation, especially of fence corners and bits of waste land, is therefore of much importance in the control of these and many other kinds of insects. The beetles may generally be found all through the summer when they especially attack the foliage of potatoes, turnips, beets, tomatoes, and many other plants. In many cases, fungus diseases, such as potato blight find suitable places for the growth of their spores in the holes made in the leaves by these beetles.

Cheese-cloth screens are very effective in warding off attacks upon young plants, such as cucumbers, etc., but where their use is not convenient or practicable the beetles may be controlled by the use of the poisoned Bordeaux mixture, the combination being effective against both the insects and the fungus diseases. For tender foliage arsenate of lead is preferable to Paris green as it is not so likely to cause injury by burning.

GRASSHOPPERS (or LOCUSTS as they should be called)—Fig. 14—are often very destructive in the later summer months, especially if the weather should be dry and hot. They are general feeders, few kinds of vegetation coming amiss to them when they are numerous and the supply of food at all scanty. Usually they are most abundant in dry pastures and the neighboring grain fields; this is due to the fact that their eggs are laid in grass lands, especially where the soil is dry and sandy, and the young nymphs grow there to maturity. They do not pass through any chrysalis stage, but gradually become bigger after each moult till the fully-winged adult state is reached. Many mechanical devices have been employed for their destruction, but the use of these troublesome methods can now be dispensed with since the discovery of the "Criddle mixture," a poisoned bait which derives its name from Mr. Norman Criddle, of Aweme, Manitoba, who proved its complete efficiency after a series of experiments. It is made and applied as follows: Take a three-gallon patent pail and fill it with fresh horse droppings, then empty into a barrel; repeat this five times. As each pailful is poured in, mix thoroughly with the manure about a quarter of a pound of Paris green and half a pound of salt which has been dissolved in water. There would thus be used about one pound of Paris green and two pounds of salt to half a barrel of manure. The mixture may be drawn in a cart to the infested places and scattered broadcast with a trowel or wooden paddle. The grasshoppers are attracted to it from considerable distances and are killed in large numbers. It has been found most

effective to distribute the mixture on alternate days, a little at a time, rather than to use larger quantities at longer intervals. In the case of grain fields, oats being especially liable to attack, the mixture should be thrown into the grain along the sides of the field and the grasshoppers will eat it in preference to anything else. Care should be taken not to allow cattle or poultry to have access to it.

PLANT-BUGS. In the American use of the word the name "Bug" is erroneously applied to insects of every kind—to a beautiful butterfly or moth as well as to a disgusting bed-bug. The name, however, when correctly employed denotes insects belonging to the order Hemiptera, which are provided with sucking and not biting mouth-parts, and which do not pass through any quiescent chrysalis stage but are gradually

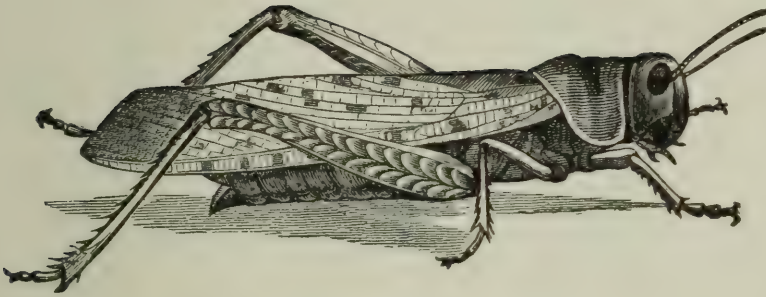


Fig. 14. Grasshopper or Locust.



Fig. 15. Tarnished Plant-bug — much magnified (*Lygus*).

developed from the newly hatched larvæ to the winged adult. To the true bugs belong two species which are very abundant in gardens, attacking plants of all descriptions, flowers and vegetables alike. These are the Tarnished and the Four-lined Plant-bugs.

The Tarnished Plant-bug (*Lygus pratensis*)—Fig. 15—is to be found all through the season on plants of almost every kind, sucking the juices of flower buds and foliage and sometimes of the leaves of young fruit trees. The mature insects are oblong in form with a triangular head and prominent eyes, and tapering to a rounded angle at the tail. The color is variable, usually grayish brown, marked with yellowish and black dashes, and having a slight bronzy reflection; its length is a little over a quarter of an inch. They are very active insects, taking flight readily when disturbed, or dodging round to the other side of the plant.

The Four-lined Plant-bug (*Poecilopsus lineatus*)—Fig. 16—is much the same size and shape as the preceding, but is yellow in color, with dark lines down the back and four black dashes along the thorax. Its at-

tacks are most noticeable in early spring, when it may be found on mint, sage, currant and gooseberry bushes, and often also on potatoes. It sucks the juices of the tender terminal leaves, causing them to shrivel up and turn black, and frequently severely injuring the plant. The standard remedy for these and other sucking insects is spraying with strong kerosene emulsion; where this cannot be applied, as in the case of many flowering plants, dusting with pyrethrum insect powder has been found quite effective. Much may be done by knocking off the bugs with a stick into a pan containing a little water covered with a film of coal-oil; this should be performed in the cool of the morning when the insects are less lively than during the heat of the day.

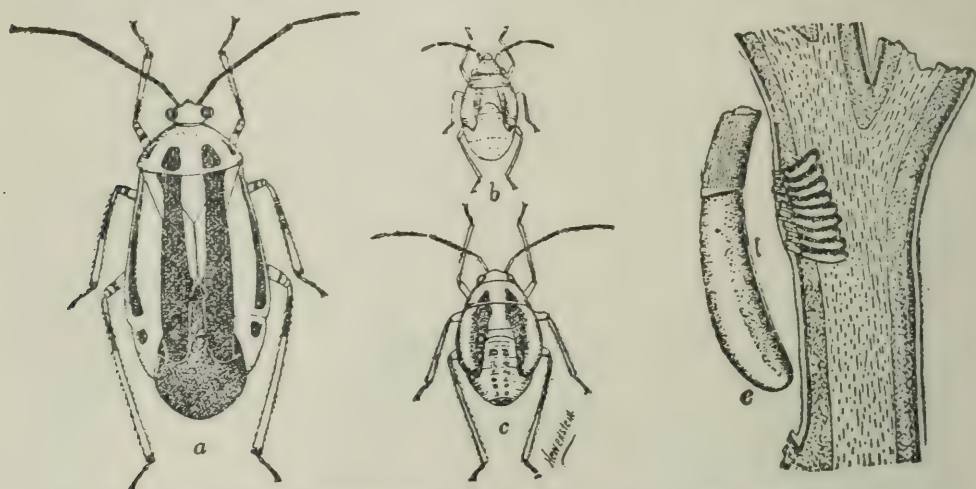


Fig. 16. Four-lined Plant-bug: *a*, adult; *b* and *c*, immature nymphs; *e*, eggs laid in a slit (*Lugger*).

WHITE GRUBS. These are the larvæ of May-beetles or "June-bugs" (*Lachnosterna*) which breed for the most part in old pastures. The beetles appear about the end of May or early in June and attack the tender foliage and buds of fruit and ornamental trees, often inflicting a considerable amount of damage. They come out at night and swarm about the trees, making a loud buzzing noise; many are attracted by lights in houses and cause some consternation among the inmates through their clumsy flight about the room and the noise that they produce; as they can neither sting nor bite no alarm need be caused by their presence. During the night they feed and by morning all disappear, hiding underground where the soil is loose and under grass or rubbish about fences and buildings. At this period boys might be employed to search for and kill them; trap-lanterns have sometimes been used with advantage, and spraying the trees they frequent with Paris green will destroy large numbers. The beetles deposit their eggs on the stems or roots of grasses just below the surface of the soil; from these the grubs hatch out and feed for two or three years underground. During the summer of their third season they change to the pupal state

and transform to beetles about September, but do not come out until the following spring. This long larval stage accounts for the fact that in some localities the beetles only appear once in three years. (Fig. 17).

The grubs, when fully grown, are thick, fat creatures, white in color—hence their name—with the body partially curled up and the last segments discolored from the food showing through the skin. When an old pasture is broken up they live for a time on the grass and roots that have been turned under and then attack whatever plant may

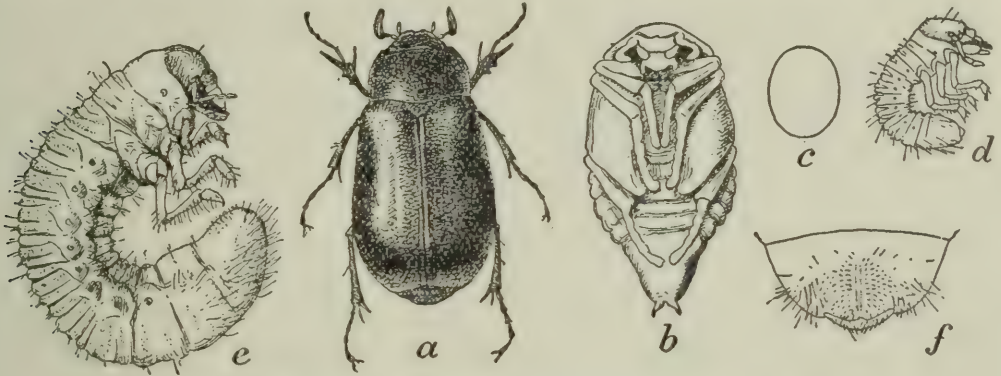


Fig. 17. White-grubs: *a*, beetle; *b*, pupa; *c*, grub; *d*, pupa
(Chittenden, U.S. Dept. Agric.)

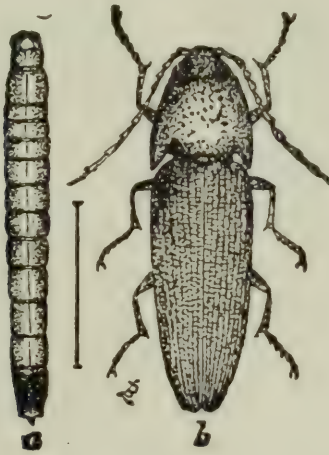


Fig 18. *a*, Wire-worm; *b*, Click-beetle.

be grown. The first and second crops usually suffer most, especially strawberries and corn; clover is least affected by them and may be seeded down with rye, then small grains followed by corn or potatoes. Late and deep plowing will break up the winter quarters of the grubs and beetles and expose them to frost and also to the various animals that prey upon them. Pigs and poultry greedily devour them; crows and other birds and skunks also destroy large numbers when they can get access to them.

In gardens digging deeply and trenching in the fall is very useful, but in the flower beds where perennials are grown this is impracticable, and therefore recourse can only be made to disturbing the soil between the plants as much as possible in late autumn and early spring. Lawns and golf-links are frequently very badly affected as they are left for many years undisturbed; sometimes the roots of the turf have been so completely eaten off that the sod may be rolled up like a carpet. In such cases the best plan is to dig up the part affected and destroy the grubs, put in a fresh layer of soil and resod or sow with grass seed. For small patches, watering with kerosene emulsion, and washing it well in with plenty of water from the garden hose, will kill the grubs. Where large areas are found to be affected on golf-links or in pastures, the most effective plan is to enclose the place with hurdles and turn in a few young pigs; they will soon root out and devour all the grubs, and may then be removed to another spot.

WIREWORMS are the larvæ of Click-beetles, so called from their curious habit of springing up in the air with a "click" when laid upon their backs. The beetles are long and narrow, rounded above, with very short legs and usually dull gray or black in color. (Fig. 18). The grubs are long and cylindrical, with a very hard integument from which they get the name of "Wire-worms," and yellow or whitish in color. The life history is very similar to that of the White-grubs; they breed chiefly in old pastures, take two or three years to mature, and feed upon the roots of any plants that may be convenient to them; they are especially injurious to corn, and often may be found during the winter feeding inside potatoes in which they burrow great holes. No treatment of the soil with salt, poisons, &c., has any effect upon them; the only remedy is a short rotation of crops as in the case of White-grubs; plowing in August and cross-plowing again in September will destroy large numbers of them. In gardens, as the beetles usually spend the winter under any shelter they can find, clean cultivation, especially along the fences, is of great importance; in spring many may be destroyed by placing bunches of clover or weeds poisoned with Paris green under shingles or bits of board where the beetles go for shelter.

ASPARAGUS.

ASPARAGUS BEETLES. The two species, the Blue (*Crioceris asparagi*) and the 12-spotted (*C. 12-punctata*), have spread over a great part of Ontario during the last few years and in many places are very abundant. Both species are often to be found upon the same plant; the former (Fig. 19) is shining blue-black in color with creamy-white blotches on the wing covers which vary a good deal in size and shape, and sometimes form a cross of the ground color of the back; the sides and the thorax are dull red and the head black. The other species (Fig. 20) is the same length, about a quarter of an inch, but is somewhat stouter; the whole insect is dull red and polished and has twelve round black spots on the wing covers.

Both these beetles pass the winter in the adult stage and are ready to attack the asparagus shoots as soon as they appear above ground in the spring; these they gnaw and spoil for table use, and the Blue species deposits upon them its shiny black eggs which are attached by the tip to the plants. (Fig 21). Later on the eggs of both species may be found upon the growing plants, and the larvæ soon appear. Those of the Blue beetle are dark olive gray grubs, which feed openly upon the foliage; the grubs of the 12-spotted are yellowish or somewhat orange in color, feeding at first upon the tender foliage, but boring into and devouring the pulp of the seed capsules as soon as they are large enough to attack. The life cycle of both kinds requires only six or seven weeks for its completion and we therefore find all through the season till sharp frosts come in the autumn, eggs, larvæ and beetles in great numbers at the same time; the pupal stage is passed beneath the surface of the ground.

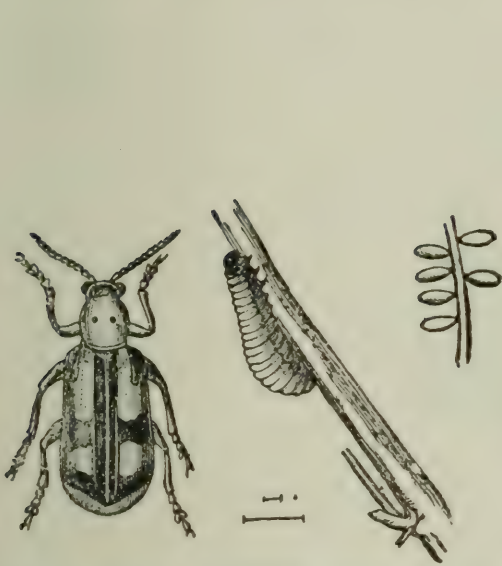


Fig. 19. Blue Asparagus beetle, larva and eggs—magnified.



Fig. 20. Twelve spotted Asparagus beetle—magnified.



Fig. 21. Blue Asparagus beetle, larva and eggs on shoot.

Remedies : The simplest and most efficient remedy is to let poultry have the run of the beds; they will devour both beetles and grubs and will not touch the asparagus.

Where this is not practicable, the young shoots should be dusted with fresh air-slaked lime when the morning dew is on the plants; this, of course, should be washed off before cooking. At the same time some of the shoots may be allowed to grow and attract the beetles which may then be killed with Paris green or arsenate of lead. If the plants have many eggs upon them, they should be cut off and burnt and others left to grow in their place.

After the cutting season is over the plants should from time to time be sprayed with one of the arsenical poisons, but when the seed capsules are formed this will be of no avail against the grubs of the 12-spotted species. To get rid of it, the seed bearing plants should be cut off and burnt. In early autumn it will be well to cut down and burn the whole of the plants.

BEANS.

The BEAN WEEVIL (*Bruchus obtectus*). This insect has only been reported from a few places in Ontario and Quebec, and does not appear to have become established as a pest. It is a very small beetle, one-tenth of an inch long, only half the size of the Pea-weevil, which in other respects it closely resembles. It is grayish brown in color, due to a coating of dense fine hair; the wing-covers are marked with a series of lines running lengthwise and have a mottled appearance. The beetle is oval in shape, the head is bent down and terminates in a short square beak; the end of the abdomen is not covered by the wings, and differs from that of the Pea-weevil in being destitute of the two oval black spots which are characteristic of the latter.



Fig. 22. Bean Weevil much enlarged and natural size; infested bean.

The eggs of the insect are laid upon the young bean pods; the grubs, as soon as they are hatched, bore through and enter the beans inside, several making their way into a single bean. Maturity is reached in the autumn, when the beetles emerge if the season is warm; otherwise they remain all winter in the ripened bean. If unmolested they will increase and multiply in the dry seeds and continue their work of destruction for a long time. It is therefore useless to hold over the seed for a year, as may be done to get rid of the Pea-weevil.

Remedy: Whenever this insect is found to be present, the beans should be fumigated as soon as practicable after they are harvested. This is done by putting them in a barrel or tight bin and pouring on them one ounce of bisulphide of carbon for every 100 lbs., and then closing the receptacle tightly and leaving it for 48 hours. At the end of this time every insect will be dead. As the fumes of this substance are inflammable and explosive, it should not be used near any light or fire.

Beans that have been injured by the insect should on no account be used as seed, as most of them will fail to germinate, or at any rate will produce only feeble plants.

The BEAN PLANT-LOUSE (*Aphis rumicis*). Windsor or Broad Beans and Horse-beans are not much grown in this country, though in some places they are found of value as an addition to ensilage. Some difficulty is experienced in obtaining satisfactory crops owing to their liability to attack by this black Aphis, which is a serious pest in Europe. At the time of flowering the colonies of this insect are to be found covering the tips of the plants so thickly that they look as if dusted with soot; if let alone they soon multiply enormously and greatly reduce the vitality of the plants.

Remedies : The most successful plan is to cut off the tips of the affected plants and destroy the colonies of Aphis by burning or trampling under foot. This has the additional benefit of checking the growth and causing the pods to fully develop. Spraying with kerosene emulsion or strong soap-suds will also be effective.

OTHER INSECTS. Beans, like other vegetables, are liable to be injured by Cutworms when the plants are small, and later on in the season by the Tarnished Plant-bug. Broad beans are also subject to attack by the Black Blister-beetle, which is one of the enemies of the potato plant, and sometimes appears in destructive numbers.

BEETS AND SPINACH

Beets and spinach are liable to be attacked by many of the common garden pests that are general feeders, such as Cutworms which bite off the young plants close to the surface of the ground, Wire-worms and White-grubs which feed upon the roots, Flea-beetles, Leaf-hoppers, the Tarnished Plant-bug and Grasshoppers which affect the foliage. Descriptions of these insects and the methods of dealing with them will be found elsewhere in the Bulletin. Mention may be made of a few other insects which occasionally attack these plants in injurious numbers.

BLISTER BEETLES. (*Epicauta cinerea*, *Pennsylvanica*, etc.)—Fig. 23—These are long, narrow, soft-bodied insects which belong to the same family (*Meloidæ*), and possess the same blistering qualities as the "Spanish-fly," which is used by druggists in the preparation of certain plasters. There are three species found in Ontario which may be distinguished by their color; the Black, the Gray and the Spotted; a fourth, the Striped, is occasionally to be found. Of these the Black is the most common and may often be seen feeding harmlessly on the flowers of the Golden-rod. At times these beetles appear in swarms and rapidly devour the foliage of beets, potatoes and a few other plants, and after inflicting a considerable amount of damage suddenly disappear. They may be controlled by spraying with Paris green, but this should not

be resorted to unless the attack is serious, as their grubs have the very useful habit of feeding upon the eggs of grasshoppers and may therefore be included amongst the beneficial insects. A better remedy, which has been employed with success, consists in driving the beetles away from an infested field by a party of men or boys walking in a line across and waving branches from side to side. The beetles thus disturbed fly ahead, and by following them up may be cleared out entirely; once they are driven out of a field they seldom return. Spraying with Bordeaux mixture will keep them off the plants, and may be employed if necessary.

The BEET LEAF-MINER (*Pegomyia vicina*) Blotches may often be seen on the leaves of beets and spinach, which are found on investigation to be caused by a minute maggot which feeds on the green tissue below the skin. The parent insect is a two-winged fly about a quarter of an inch in length, which deposits its eggs on the foliage of these plants;

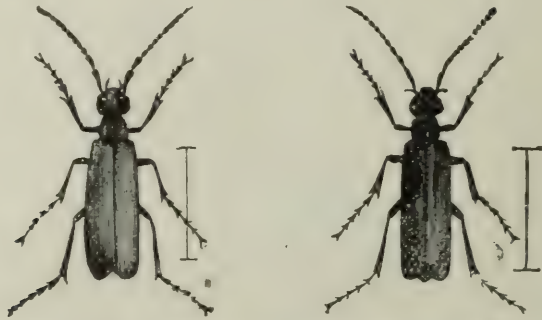


Fig. 23. Blister beetles—magnified.

the maggots when hatched immediately burrow beneath the surface and cannot therefore be reached by any applications. The only method that seems at all available is to pick off and destroy the infested leaves, a laborious plan which can only be adopted where the plants are grown on a small scale. If the attack is serious it would be worth while to adopt this method in order to get rid of the trouble and guard against its repetition.

CATERPILLARS. The foliage of beets and spinach is liable to be attacked by some caterpillars, but as a rule they are in small numbers, widely scattered over the plants and seldom inflicting much damage. This does not apply to the extraordinary outbreaks on rare occasions of the Army-worm and the Variegated Cutworm, which devour every green thing that they come to, beets as well as everything else. Among the others referred to may be mentioned the Yellow Woolly-Bear (*Diacrisia virginica*), which is a hairy caterpillar, readily seen from its bright yellow color, and attaining to an inch and a quarter in length when fully grown.—Fig. 24—It turns into a beautiful snow-white moth, with a few black dots on its wings and rows of black and yellow spots

on its body. When feeding they are conspicuous, and may be picked off by hand; but usually they are beneath the leaves when at rest. If very numerous, Paris green may be employed. They are general feeders and do not confine themselves by any means to garden vegetables, but attack many kinds of weeds as well.

CABBAGE AND CAULIFLOWER.

These plants are subject to a series of attacks by insects from their first appearance above ground to maturity. Cutworms destroy a great many seedlings and young plants when they are set out in the spring. Later on Plant-lice make their appearance, and cover the leaves with their colonies, sucking out the sap and causing the foliage to dry up and wither; they become excessively numerous towards the close of the season, and in addition to the injury they inflict, cause the plants to

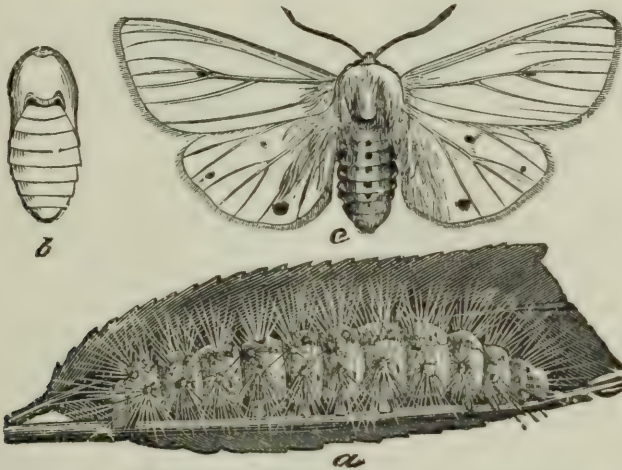


Fig. 24. Yellow Woolly-bear : *a*, caterpillar ;
b, chrysalis ; *c*, moth.

present a disgusting appearance. Throughout the summer the leaves are liable to be devoured by several caterpillars and in August and September by Grasshoppers, while the roots are frequently caused to rot by the Maggots of a small fly. Aphids and Cutworms and other general feeders are treated elsewhere; reference will therefore be only made here to such insects as are peculiar to the Cabbage and other Cruciferous plants.

The WHITE CABBAGE BUTTERFLY (*Pontia rapæ*)—Fig. 25. This insect, which came to us from Europe about fifty years ago, is now one of our commonest butterflies, and may be seen flitting about everywhere from early spring till cold weather sets in. It is one of the worst pests that the cabbage grower has to contend with unless measures are taken to prevent its ravages, and happily this is a matter of no great difficulty. The butterfly lays her eggs on the leaves of the food-plant; the

caterpillars are velvety green and almost exactly the color of the leaves upon which they are feeding; when at rest they lie at length upon the midrib and are not easily seen. There are two broods in the year, the later being much the more numerous, and sometimes a third if the autumn should be fine and warm. The caterpillars riddle the outer leaves and then burrow into the heads, devouring the substance and spoiling the plant for table use by their excrement. Besides Cabbages and Cauli-flowers they attack also mignonette, stocks and nasturtiums.



Fig. 25. White Cabbage Butterflies.

Remedy: Pyrethrum insect powder is thoroughly effective. One pound should be mixed with four pounds of cheap flour and kept in an air-tight jar or canister for twenty-four hours so that the poison may be thoroughly incorporated with the flour. The plants infested by the caterpillars should then be dusted with the mixture which can be applied with a small bellows, or in a cheese-cloth bag tapped lightly with a slender rod. This powder will kill insects, but is perfectly harmless to human beings. Another method, which is more rapid in its effects upon the worms, is to dissolve two ounces of the Pyrethrum powder in three gallons of lukewarm water and spray at once. The liquid kills immediately all the caterpillars it reaches, while the dry powder often takes many hours to produce the same result. Paris green and other virulent poisons should never be applied to Cabbages and vegetables of any kind that are intended for table use.

The ZEBRA CATERPILLAR (*Mamestra picta*)—Fig. 26. There may often be found feeding upon Cabbage and some other garden plants of the same family, a handsome caterpillar about two inches long, when fully grown. It is velvety black on the back and has two bright yellow stripes along the sides, which are connected by a series of irregular yellow lines on a black ground-color; the head and feet are reddish. These strikingly contrasting colors render the caterpillar a conspicuous object on the green foliage that it feeds upon, and make it an easy task to pick them off by hand. There are two broods in the year, the moths, which are dull reddish-brown with white underwings, appearing in May and August. The young caterpillars, when first hatched, feed in colonies and devour the green substance of the leaves, thus producing white blotches on the foliage and rendering their presence easily noticeable. Should they be too numerous to be destroyed by hand picking, resort may be had to Pyrethrum powder applied as mentioned above, or to



Fig. 26. Zebra Caterpillar and Moth.

white hellebore which may be dusted on the leaves or sprinkled by mixing one ounce in two gallons of warm water, stirring from time to time to prevent the powder from settling at the bottom of the watering can.

The CABBAGE PLUSIA (*Autographa brassicæ*, Riley)—Fig 27. A pale green caterpillar, with whitish lines running lengthwise of the body, may sometimes be found devouring the leaves of cabbages, lettuce and other vegetables, feeding usually on the under side of the foliage. It is called a "semi-looper" from its raising the middle of the body when walking, owing to the absence of some of the usual prolegs. Though abundant and destructive in the neighboring States, it has not often been found in injurious numbers in Ontario, but may at any time prove a serious pest. In the early part of the season they may be got rid of

by dusting with a mixture of one pound of Paris green in twenty pounds of lime, applying the powder to the under side of the leaves. A liquid spray may also be used of the ordinary composition.

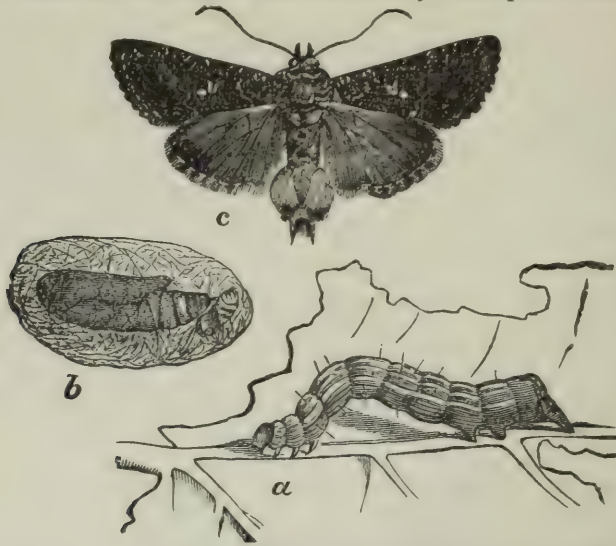


Fig. 27. Cabbage Plusia : caterpillar, chrysalis and moth.

THE DIAMOND-BACK MOTH (*Plutella maculipennis*, Curtis)—Fig. 28—is from time to time a serious pest, as its caterpillars appear in large numbers and devour the foliage of cabbages, turnips and other cruciferous plants. These worms are much smaller than those of the preceding species; are green in color, and remarkably active when disturbed;

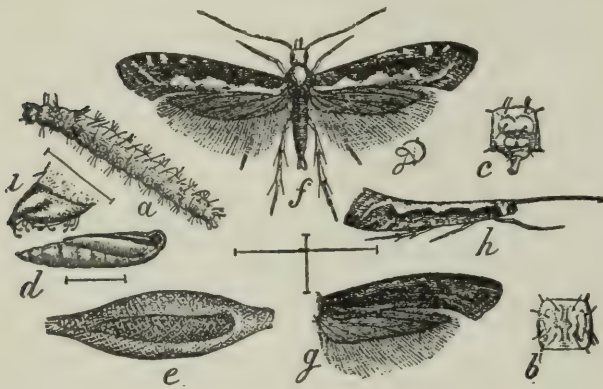


Fig. 28. Diamond-back Moth : a, caterpillar ; d, pupa ; e, cocoon ; f and h, moth—all much enlarged.



Fig. 29. Cabbage Maggot, puparium and fly—enlarged.

they will then wriggle about in a violent manner and drop to the ground by a silken thread from the leaf on which they are feeding. As they devour all the green substance of the foliage the plant attacked soon withers and dies. There are usually two broods in the year, the first

set of caterpillars appearing at the beginning of July, and the second towards the end of summer; in favorable seasons there may even be a third. The winter is spent in the pupal stage, the lace-like cocoon enclosing the chrysalis being attached to the under side of the leaves. The moth is a beautiful little creature, dark or ashen gray in color, with a series of white marks on the forewings which form, when the wings are closed, a row of diamond-shaped markings down the middle of the back; from this characteristic the moth receives its name.

The remedy that seems most effective is spraying the underside of the leaves wherever attacked with kerosene emulsion, at the same time applying fertilizers, such as nitrate of soda, to induce a vigorous growth. As a preventive measure all remains of stalks and foliage, after the crop has been taken in, should be destroyed in order to get rid of the wintering chrysalids. Though the insect is an importation from Europe, it is largely kept in check by parasites and only occasionally becomes a serious pest.

The CABBAGE MAGGOT (*Phorbia brassicae*)-Fig. 29—is one of the most serious insects that growers of this vegetable have to contend with. Young plants, soon after being set out in the spring, are often found to have their roots infested with these maggots, their presence being indicated by the dying of the plants. They are white, footless larvæ, the offspring of slender two-winged flies, smaller than the ordinary house fly; the eggs are laid on the stems of the plants close to or just beneath the surface of the ground; when hatched, the maggots burrow down into the roots, where they tear the tissue with the hooks which take the place of their jaws, and live upon the sap; the breaking up of the cells of the plant causes a rot to set in and the entire destruction of the root soon follows. When full grown the maggots form their reddish brown puparia in the soil near by, and from these a second brood of flies soon emerges. Working under ground as they do, it is a difficult matter to apply any effective remedy; the only one that has proved useful is a decoction of pyrethrum insect powder (quarter of a pound to a gallon of water) or white hellebore of the same strength. The earth is drawn away from the root of an affected plant and half a tea-cupful is poured in; the soil is then replaced and hilled up around the stem.

Preventive measures are less troublesome and usually more effective. One of the best is the screening of newly set-out cabbages and cauliflower flowers with cheese-cloth. Light frames of slats are made 8 feet long, 2 wide and 2 high; over these is tacked cheesecloth which should reach to the ground on all sides, and prevented from blowing about by heaping a little earth on the edges. These frames cost very little and can be readily moved when required and stowed away for future use; they should be put on as soon as the plants are set out and left till they are well-grown. The frames not only prevent the flies from laying their eggs on the plants, but also keep off the other insects which are liable to attack them.

Tarred paper disks, three inches in diameter, with a slit from one side to the middle, are used to place around the stems of plants when they are set out, and prevent the flies from laying their eggs upon them. These are somewhat troublesome to make and put on and are not nearly so effective as the cheese cloth screens.

CARROTS.

THE BLACK SWALLOW-TAIL BUTTERFLY (*Papilio asterias* [*polyxenes*])—Fig. 30. There may often be found feeding on the foliage of carrots and parsnips a handsome velvety green caterpillar ornamented with bands of yellow. This is the larva of one of our largest and most beautiful butterflies, black in color, ornamented with rows of bright yellow spots. The caterpillars do not feed in colonies and consequently are not often injurious, the amount of foliage consumed by an individual



Fig. 30. Black Swallow-tail Butterfly.

seldom affecting the vitality of a plant. Being conspicuous, they may, if sufficiently numerous to require repression, be picked off by hand and crushed under foot. They are kept in check, however, by a large parasitic fly, which lays an egg on a caterpillar from which hatches out a grub that feeds within the body of its host until the chrysalis is formed, and then completes its work of devouring all that remains, a fly with four clear membranous wings coming out instead of the butterfly.

The CARROT RUST-FLY (*Psila rosæ*)—Fig. 31—is a much more serious enemy to the plant than the preceding species. It is a comparatively recent importation from Europe, having been first observed in this country about twenty-five years ago. It is a great pest in the Maritime Provinces, but so far is only locally found in Ontario. Its attack may first be noticed in spring when the leaves of young carrots turn reddish, and on examination the roots will be found covered with rusty

blotches—hence the name of the insect. The parent of the mischief is a small two-winged fly, quarter of an inch long, body dark green, head and legs pale yellow and the eyes red. From the eggs, which are laid on the stem below the surface of the ground, the young maggots make their way into the root, and tear the tissues in a similar manner to the cabbage maggot described above; the attack causes the rusty blotches to appear. The maggots of a later brood infest the full-grown roots and continue their work of destruction in the root-house during the winter. Celery and parsnips are also attacked.

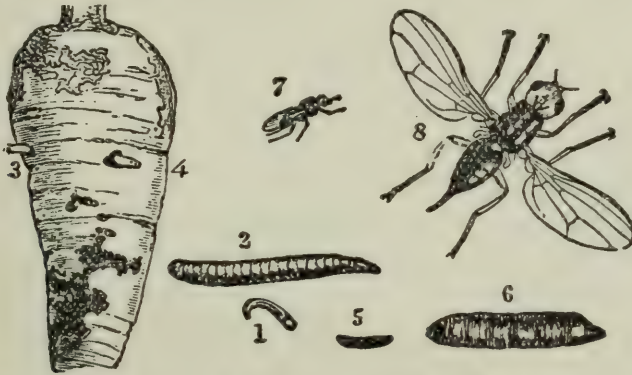


Fig. 31. Carrot Rust-fly : 1, 3, 4, 5, 7 natural size ;
2, 6, 8 enlarged.

Preventive measures seem to be the only remedies available. To deter the fly from laying her eggs, the rows of young carrots, when ready for thinning out, should be sprayed with kerosene emulsion, or dusted with sand or plaster in which coal-oil is mixed, half a pint being used to a pailful of the material. The application should be made weekly, and especially after hoeing, until about the middle of July.

In gardens where carrots are grown for table use and size is not an object, late sowing is found to be advantageous, the plants thus escaping the egg-laying of the fly. Repeated sowings a week or so apart, will secure the freedom of some of the crops from attack. The plants should not be grown two years running in the same piece of ground. Stored roots, if found affected in the winter, may be treated with carbon bisulphide, one ounce to 100 lbs. of roots, placed in pans on top of the pile, provided that they are in fairly air-tight bins. They should be left for 48 hours and then exposed to the air in order to get rid of the fumes, which are very inflammable; no light or fire should be anywhere near when this substance is being employed.

CELERY.

Celery, as a rule, is not much affected by injurious insects; those that do attack it are the same as the enemies of carrots and parsnips. to which reference is elsewhere made. The handsome caterpillars of the Black Swallow-tail Butterfly (*Papilio asterias*)—Fig 30—may often

be found eating the foliage, but they are never very numerous and can easily be controlled by handpicking. A small caterpillar called the CELERY LEAF-TYER (*Phlyctænia ferrugalis*) is sometimes abundant and injurious; it feeds for the most part at night; when young it eats small holes in the leaves which are hardly noticeable, but as it grows larger it becomes more voracious and consumes a considerable amount of foliage. When fully grown they roll up a leaf and tie its edges together with silk, forming thus a convenient case in which to pass the chrysalis stage. The moth is about three-fourths of an inch in expanse of wings, pale brown in color, with a reddish suffusion; the wings are marked with irregular cross lines of black and some circular spots. There are at least two broods in the year. The insect is sometimes known as the Greenhouse Leaf-tyer from its attacking a variety of hot-house plants; out-of-doors it by no means confines itself to celery, but may be found on a great variety of vegetables. As soon as the caterpillars are noticed the plants attacked should be sprayed with Paris green, applied to the under side of the leaves. In the green house any infested leaves should be cut off and destroyed.

One of the most serious enemies of celery is the Rust-fly described among the insects affecting carrots. The maggots attack the thick part of the roots of young celery plants and prevent their proper growth; they also produce the characteristic rusty blotches on the stems and spoil them for table use.

CORN.

The insect enemies of Indian Corn are legion, and may be found attacking every part of the plant, root and stem, leaves and ears, the tassel and silk, and the ripe harvested corn; about 350 different species are recorded from North America. Happily a large number of these insects are not found in Canada, and many others are only of occasional occurrence; it is, therefore, unnecessary to describe more than a few species which are always with us and against which constant warfare has to be waged.

Attacking the roots we find White-grubs and Wire-worms very destructive, especially where corn is planted on old pasture land broken up a year or two before. These insects have already been described. Another serious enemy is the Corn Root-aphis, which is attended by its ant protectors; it is especially injurious to the plants when young. The winged forms migrate to various common weeds such as plantain, pigweed, &c., showing the importance of keeping fields and gardens free from these places of refuge.

As soon as the tender blades of corn appear above the soil they are liable to be cut off by these nocturnal marauders, the Cutworms, which can be circumvented by the use of the poisoned bran-mash. The grubs of the 12-spotted Cucumber beetle often infest the roots of corn when

the plants are young, and a great deal of loss is occasioned by them. Later on, as the plants grow bigger, they may be attacked by Grasshoppers and seriously injured.

The CORN STALK-BORER (*Papaipema nitela*)—Fig. 32—is an occasional destroyer of the plant. The caterpillar, which grows to an inch and a half in length, lives inside the stem and devours all the interior to such an extent that the plant withers and dies; when approaching maturity the worm works its way down to the root and there changes to the chrysalis stage. The moth, which is fawn-colored and has the front pair of wings crossed by a pale curved line, comes out in the autumn and lays her eggs on the stems of a variety of plants as well as on the

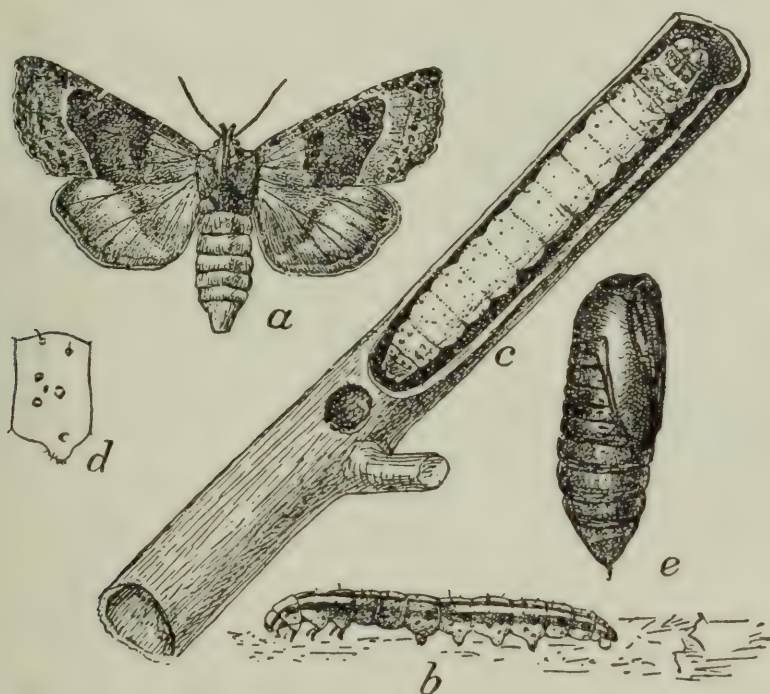


Fig. 32. Corn Stalk borer : *a*, moth ; *b*, half-grown caterpillar ; *c*, mature larva in stalk ; *e*, pupa.

(Chittenden U.S. Dept. Agric.)

corn. The caterpillar is known to infest the tomato, potato, dahlia, and many other cultivated plants as well as many kinds of weeds. The only remedy seems to be clean cultivation and the destruction in the fall of all stems and roots of plants which are likely to have eggs laid upon them. Being an internal feeder there is no way of poisoning the caterpillar, and usually its presence in a stalk is only known by the premature withering of the plant.

The CORN EAR-WORM (*Heliothis armiger*)—Fig. 33—is another general feeder which includes corn in its attacks. In the south it is the notorious “Boll-worm” which is so destructive to cotton; here it

attacks tomatoes and a few other plants as well as corn. The presence of the caterpillar is first made known by small holes to be seen in the leaves enveloping the growing ear; on investigation the worm will be found devouring the milky grains and spoiling the ear by its excrement and the rot which usually sets in; sweet corn is especially liable to be spoilt by this attack. Any ear that is seen to be affected should be opened and the caterpillar destroyed; this seems to be the only thing that can be done. The moth is a handsome creature, ochre yellow in color with darker bands across the wings, which measure an inch and a half when expanded. With us there is but one brood in the year and much may be done to keep the insect in check by clean cultivation in the fall of the year.

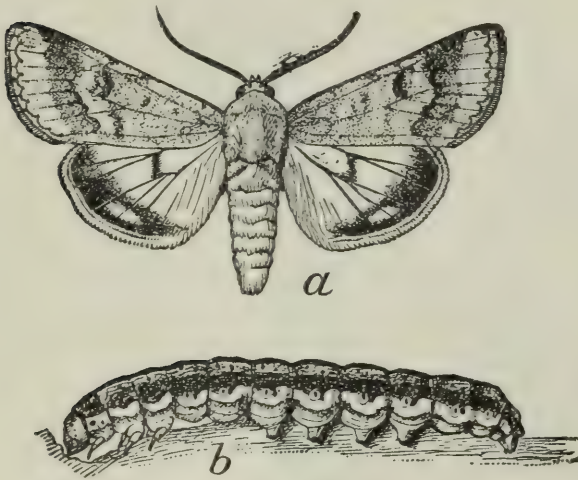


Fig. 33. The Corn Ear-worm : a, moth ;
b, caterpillar.



Fig. 34. Chinch-bug,
greatly magnified.

In the great corn-growing States to the west and south the crop is very seriously injured year after year by the Chinch-bug (Fig. 34), a small black bug, with a white mark on each side of the wings. As it appears in millions, these hosts inflict an enormous amount of damage by sucking out the juices of the plant. We are fortunately free from this pest in Canada, though an occasional specimen has been found in Ontario.

CUCUMBER AND MELON.

CUCUMBER BEETLES: the Striped (*Diabrotica vittata*)—Fig. 35—and the Spotted (*D. 12-punctata*). The former of these insects may be found all through the season on cucumbers, melons, squashes and pumpkins from the time that the plants are first set out till the frost destroys the foliage in the autumn. The beetles hibernate in the adult stage and are ready to attack the seedling plants as soon as they appear above the soil; oftentimes they are sufficiently numerous to kill the tender plant

by eating the leaves and gnawing the stem; later on they may be found in the flowers, where, however, they seem to feed on the nectar and not to do much harm. The beetle is less than half an inch in length, oval in shape, yellow in color with a black head and three black stripes down the back. The larvae are slender white grubs which feed upon the roots of the plants and sometimes burrow up into the stem, continuing their injuries for about a month, when they change to the pupal stage and later on come out as a second brood of the beetles. The latter are very lively insects, flying quickly from plant to plant when disturbed; sometimes when their usual food is not available they attack the young pods of peas and beans, and may be found on a variety of other plants.

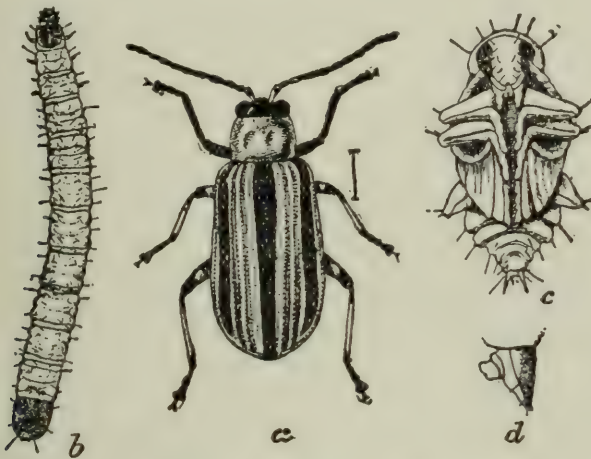


Fig. 35. Striped Cucumber Beetle, grub and pupa—much enlarged,



Fig. 36. Spotted Cucumber Beetle enlarged.

The Spotted Cucumber beetle (Fig. 36) is larger than the Striped, and less oval, broadening considerably towards the posterior end of the body; its color is yellowish green, with a black head and three rows of four black spots, making twelve in all, on the wing covers. It is a more southern insect than the Striped beetle, and in many parts of the United States it does serious injury to the roots of corn. In Ontario it is usually found associated with the other species on cucurbitaceous plants, but in fewer numbers; it is also a much more general feeder, attacking a great variety of plants; its life history is somewhat similar to the preceding, but it seems to feed mostly upon the pollen of blossoms in the beetle stage, the grubs being the chief cause of injury by their attacks upon roots and stems.

The treatment for both these insects is chiefly preventive. Young cucumber and melon plants should be protected as soon as they are set out with the cheese-cloth screens described as a protection against the Flea-beetles, or by smaller screens made with two flexible sticks crossed at right angles and with their ends securely fixed in the ground,

and then covered with a piece of cheese-cloth which can be kept from being blown about by heaping a little earth on the edges. These screens may be safely removed when the plants have grown too big to be covered by them. Another plan is to grow a few squash plants earlier than the others so as to attract the beetles to them, and then treat them with Paris green, one pound mixed with 50 lbs. of lime or plaster; this may be dusted over the plant when the beetles congregate upon it. In the autumn all the refuse of the vines should be gathered up and either burned or buried in a compost heap, so as to kill the hibernating beetles. Spraying the young plants with poisoned Bordeaux mixture has also been found effective.

The SQUASH-BUG (*Anasa tristis*)—Fig. 37. This familiar insect is usually very abundant and injurious through all the south-western counties of Ontario, but during the last two or three years it has almost entirely disappeared. It will not be long before it again becomes numerous and troublesome. The bugs are much larger insects than the beetles described above, being nearly three quarters of an inch in length, of a dirty blackish color above and speckled creamy beneath; they have the usual repulsive odor common to the "stink-bugs," to which family they belong. Late in autumn the bugs may be found in all sorts of places, crawling about in search of winter quarters, and should then be crushed under foot. In the spring they come out, and begin their injurious work of sucking out the juices of young cucurbitaceous plants. The eggs, which are metallic in color, are laid in batches on the under side of leaves near the base of the plant; from them soon hatch out the young bugs, but not all at once, so that we may find nymphs of all sizes on the under side of the same leaf. They not only injure the foliage by sucking out its juices but also poison it as well, causing a speedy wilting of the leaves they attack. If any withering leaves are observed they should at once be inspected, and if a colony is found at work it can soon be exterminated by crushing under foot.

These bugs are difficult to get rid of as the usual remedies for sucking insects, kerosene emulsion, for instance, have but little effect upon them, except when applied to the colonies of young nymphs. The methods recommended above for the Cucumber beetles are also the best remedies for these disagreeable insects. In the early part of the season the parent bugs may be trapped by laying pieces of shingle or board near the plants; the bugs will be found taking shelter under them in the morning and can easily be destroyed.

FLEA BEETLES, described above, are often very injurious to young cucumber and melon plants, and also a species of Aphis. Occasionally the fruit is attacked when green by small caterpillars, one called the Pickle-worm (*Diaphania nitidalis*) and another, the Melon caterpillar (*D. hyalinata*); both turn into beautiful little moths. In the south they are regularly injurious year after year, but with us, happily, they are quite rare; should they become numerous at any time they could be easily controlled by the use of arsenical poisons.

ONION.

THE ONION MAGGOT (*Phorbia ceparum*)—Fig. 38—is very similar in mode of attack and life-history to the Cabbage Maggot already described; it is unnecessary, therefore, to repeat these particulars. It is often extremely destructive, and has almost driven market gardeners to



Fig. 37. Squash-bugs: *a* to *e*, nymphs, in different stages of growth; *f*, adult bug—much enlarged.

despair. The preventive measures referred to above are hardly suitable for a plant whose style of growth is so different from that of a cabbage, and few persons would take the trouble to protect onion beds with cheese-cloth screens nor could tarred paper disks be employed. There

is, however, a simple method of protection which has been found effective: as soon as the tiny shoots of the onions begin to appear above the soil, the rows should be treated with a whitewash made of lime and water and thick enough to form a thin crust over the surface. The effect of this is to close up all crevices and openings in which the parent fly would lay her eggs, and prevent the maggots which may hatch from any eggs laid above ground from reaching the roots beneath. The young plants penetrate through the thin crust of lime without difficulty.

Later on, when hoeing, any plant that is not growing satisfactorily should be cut out and crushed under foot so as to destroy the maggots. Furthermore, onions should not be grown a second time on, or close to, a bed which has been infested with these insects. Pyrethrum insect

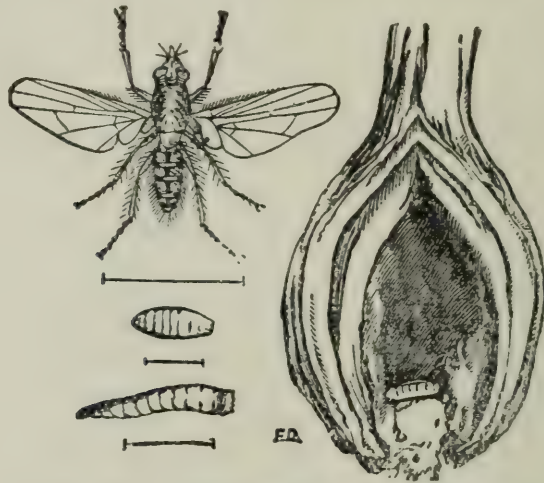


Fig. 38. Onion Maggot, puparium, fly and infested bulb.

powder or white hellebore may be applied in the same manner as recommended for the cabbage maggot. Many other substances, such as salt, plaster, Paris green, &c., have been tried without any satisfactory results. When taking up the onions in the fall any bulbs infested by maggots should be carefully destroyed.

PARSNIP.

The PARSNIP WEBWORM (*Depressaria heracliana*). When parsnips are left in the ground all winter and allowed to grow up for seed-bearing purposes during the following season, they are very liable to be attacked by this insect. Towards the end of June when the stems are tall and bear fine umbels of flowers, it is often found that the bloom is disfigured with webs which draw the whole into an untidy mass, and on examination a colony of small caterpillars will be found at work within. When they have finished consuming the flowers, they burrow

into the stem and feed upon the soft inner lining; here they change to the chrysalis stage during the latter part of July, and are often so numerous that the hollowed stems will be found packed with larvæ or pupæ. The caterpillars are of a dirty green color above and yellowish on the sides and beneath; most of the segments are furnished with shining black warts, each of which terminates in a fine bristle. The moths come out about the first of August and hibernate in any shelter that they can obtain, often coming into houses for the purpose; they are dusky gray in color, with no conspicuous markings, and with the body much flattened; the expanse of the wings is less than an inch, and the length of the body under half an inch. The insect is an European species.

These caterpillars may be found in abundance working in a similar manner on celery plants that have grown up for seed and on wild carrot and other kindred umbelliferous plants. In the garden they should be treated with Paris green as soon as they are noticed; if the umbels are drawn into a web they should be cut off and burnt, and if the stalks are perforated the same operation should be performed on them. Wild carrots and parsnips should be cut down wherever they may be found in neighboring fields or waste places.

Parsnips are also attacked by the insects already mentioned in connection with carrots and celery.

PEAS.

THE PEA-WEEVIL (*Bruchus pisorum*)—Fig. 39. The life-history of this insect resembles in many respects that of the Bean-weevil, already described. The beetle is about one-fifth of an inch in length, brownish-gray in color, with two conspicuous oval black spots on the end of the abdomen which is not concealed by the wing-covers. The head is bent under the front of the body and ends in a square-cut beak. When peas are in blossom these little beetles may be found upon them, waiting for the young pod to be disclosed; on it the minute eggs are laid, and the grubs, as soon as hatched, bore through and enter the small green peas, one beetle only infesting a single pea. Here the grub remains, feeding upon the substance of the pea, passing through the pupal stage, and only attaining maturity when the peas are ripe and ready for harvesting. Most of the beetles remain inside the peas until they are sown the following spring, but some emerge when the peas become ripe and remain in the field or in the barn all winter. Unlike the Bean-weevils, this species does not increase and multiply in the stored peas but will die if they are kept over for another year.

Treatment: The pea crops should be harvested early, a little on the green side, so that the pods will not shell out before removal from the field; threshing should be done as soon as possible, and all refuse from the machine should be swept up and burnt. If any weevils are noticed in the peas, the crop should be put into bins or barrels and fumigated with carbon bisulphide in the manner recommended for the Bean-weevil.

Peas that contain weevils, even though they are dead, should not be sown, as the plants grown from them will be stunted owing to the lack of food material in the pea; a considerable proportion would probably not grow at all, owing to the germ having been devoured by the beetle. The remains of the crop, not taken from the field, should be raked up and burnt. If every pea-grower would adopt these methods we should soon be rid of the pest, as the beetle does not attack any other plant.

The PEA MOTH (*Semasia nigricans*)—Fig. 40—is not often found in Ontario, but is very common and at times extremely destructive in the Maritime Provinces; its occasional occurrence with us renders it necessary to be on our guard against it. The parent moth is small, less than half an inch in expanse of wings, and of a dull slaty-grey color. It lays its eggs on the growing pods of peas; the caterpillars soon hatch out and bore their way into the pod where they feed upon the young peas, con-



Fig. 39. Pea-weevil, natural size and much enlarged.



Fig. 40. Pea-moth and caterpillar; moth greatly enlarged and natural size; affected pea.

suming many of them and filling the space with a mass of excrement. When full grown the worms leave the pods and form their small oval cocoons below the surface of the ground.

Where there is reason to expect an attack, the pea vines should be sprayed as soon as blossoming is over with a liquid wash of one pound of soap in twenty-five gallons of water in which has been thoroughly mixed four ounces of Paris green; the spraying should be repeated a couple of times at intervals of a week or ten days. The object is to poison the young caterpillars when they are eating their way through the pod.

Sowing early varieties as early as possible in the season has been found useful, the pods being too far advanced to be injured when the worms appear. Very late sowing is also recommended in order that the blossoming may not take place till after the moths have ceased egg-laying.

An important point is to plow or dig deeply in the fall any piece of land where infested peas have been grown in order to bury the cocoons and prevent the moths coming out in the spring. All unripe pods should be burnt as they may contain worms, and peas should not be grown again upon or near the same piece of ground the next season.

The PEA APHIS (*Nectarophora destructor*). This large green plant-louse has during recent years become extremely destructive to the vines of peas. In some parts of the neighboring States, where large acreages were devoted to this crop for canning purposes, the annual loss was estimated at many millions of dollars, three-fourths of the crop being in some instances destroyed. The usual remedies for plant-lice have already been referred to under "Aphis," but they are of little value when contending with an attack on a very large scale. A method that has been found effective is to sow the peas with drills and wide enough apart for a cultivator to work between the rows, instead of the usual broadcast plan. As soon as the plants are seen to be infested boys are employed



Fig. 41. Colorado Potato-beetle.

to brush the insects off, and they are followed at once by the cultivator, which buries the lice and prevents their getting back on the vines. The operation has to be repeated a few times, but the results have proved entirely satisfactory and to warrant the labor and expense.

POTATO.

The COLORADO POTATO BEETLE (*Leptinotarsa decemlineata*)—Fig. 41—is so familiar to everyone that it is hardly necessary to give any description of the destructive creature. The adult beetles come out of

their winter hiding places about the end of May and feed at once upon the earliest appearing potato plants; soon after this the females lay their bright orange colored eggs on the under side of the leaves in batches of various numbers up to fifty or more. The grubs hatch out in about a week and set to work to devour the foliage; their dark orange color renders them somewhat conspicuous, so that an attack can hardly fail to be noticed. When fully grown the insect changes to the pupal stage in a cell a few inches below the surface of the ground. A period of about eight weeks is required to complete a life cycle, and then a second brood of beetles appears, lays its eggs and starts new colonies of grubs; the third brood comes out in September and may be observed crawling or flying about in search of winter quarters. The broods are by no means distinct, as all the grubs do not mature at the same time, consequently the insect may usually be found in all its stages at any time during the summer.



Fig. 42. Three-lined Potato-beetle.



Fig. 43. Three-lined Potato-beetle; eggs, larva and pupa.

The well-known and long-tried remedies are Paris green or arsenate of lead combined with Bordeaux mixture, the latter ingredient assisting in warding off the attacks of fungus diseases and also in destroying Flea-beetles, when they are present, as they commonly are. Spraying should be done early in June as soon as any grubs are to be seen, again a month later and three times, at intervals of a fortnight, between the end of July and the first of September.

The THREE-LINED POTATO BEETLE (*Lema trilineata*)—Fig. 42—looks very like the Striped Cucumber beetle, but is larger and of a darker yellow color. Before the coming of the Colorado beetle, this was the chief insect enemy of the potato, but now, though common, it is not usually particularly destructive; its life-history is much the same, the adult beetle coming out in the spring and laying her eggs on the under side of the leaves of the young plants; these are yellow in color and are laid along the midrib of the leaf. The larvæ have the extraordinary habit of piling their excrement on top of their backs, possibly as a protection against their enemies, and thus present a disgusting appearance (Fig. 43)

43). The grubs appear in June and go through their transformation in time for another brood to come forth in August; the beetles from this later brood do not emerge till the following spring.

When this insect is at all abundant, it can easily be controlled by the application of Paris green; the measures everywhere taken to check the Colorado beetle have no doubt prevented this species also from becoming numerous.

The POTATO FLEA-BEETLE (*Epitrix cucumeris*) is one of the most serious pests of the potato plant. The tiny creature—it is less than one-twentieth of an inch long—eats small holes all over the surface of the leaves and causes much injury in this way; but a worse result is that the spores of the fungus diseases called “Blight” find a suitable place in these holes for germination and the complete destruction of the leaf soon follows. Flea-beetles as a class have already been referred to; it is unnecessary, therefore, to do more than state that spraying with Bordeaux mixture is a satisfactory remedy for both the insect and the blight.

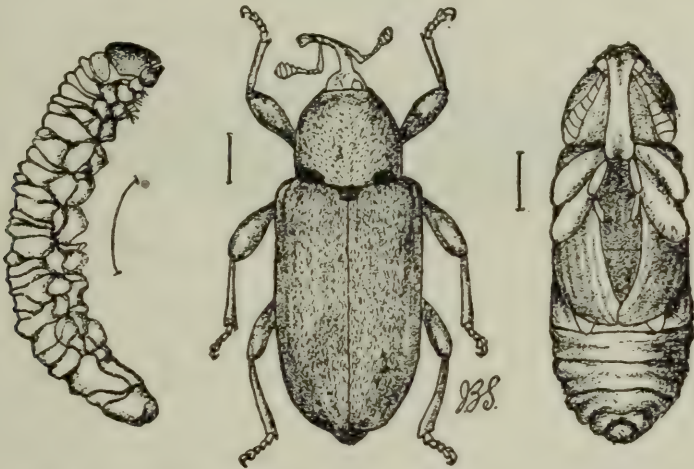


Fig. 44. Potato Stalk-borer ; beetle, grub and pupa.

BLISTER BEETLES are often reported from the northern parts of the Province as appearing suddenly in great swarms in the potato fields and greedily devouring the foliage. An account of them has already been given under insects attacking Beets and Spinach.

The POTATO STALK-BORER (*Trichobaris trinotata*)—Fig. 44—is an occasional cause of injury to the plant in this country, but in some of the States to the west and south it is considered almost as great a pest as the Colorado beetle. As the name indicates, the attack is made by boring the stalk; this is done by the grubs, which are whitish in color and without legs. The small beetles, about quarter of an inch long, are ashen-grey in color and belong to the family of weevils or snout beetles, having the head developed into a long beak; the base of the wing-covers is marked with three distinct black spots, which

readily distinguish it from similar species. About the month of June the parent makes a hole in the stalk of the potato with its snout and deposits an egg and repeats the operation a number of times. The grubs which hatch from them burrow up and down in the stalks, devouring the interior, and when full-grown, about the beginning of September, form their cocoons inside the stalk near the base of the plant; the beetles emerge later on but remain in this retreat all winter.

No application of poison is of any avail, as the grubs are out of reach in the stalk, but much may be done to exterminate the insect by cleaning up and burning all the remains of the plants after the potatoes are dug in the fall; this is advisable also in order to destroy the germs of fungus diseases.



Fig. 45. Tomato-worm.



Fig. 46. Chrysalis of Tomato-worm.

RADISH.

Radishes are very liable to attack and serious injury when they first come up in the seed beds by the minute Flea-beetles described among the insects that are general feeders; cheese-cloth screens are found to be the best protection. The Radish-magot (*Phorbia*) is the same or a very closely allied species to that which attacks the roots of cabbages, and may be treated in much the same way; protection with cheese-cloth is by far the simplest and entirely effective method of securing perfect radishes in the spring.

TOMATO AND TOBACCO.

These two plants may be associated together as the same insects are liable to attack both; but it is highly probable that the growth of tobacco on a large scale in the south-western counties of Ontario will cause other enemies of the latter plant to make their unwelcome appearance. Cutworms early in the season are very destructive to the young

plants, but may be warded off by the use of the poisoned bran-mash. The leaves are liable to be attacked by the Flea-beetles, the Tarnished Plant-bug and Grasshoppers. The most conspicuous enemy of both plants is

The FIVE-SPOTTED HAWK MOTH, or Tomato worm (*Protoparce celeus*). This is a large caterpillar, attaining to a length of nearly four inches when fully grown and correspondingly thick (Fig. 45); it has a series of oblique pale lines along the sides and a prominent tail; in color there are three varieties, pale green, dark green and almost black. They are very voracious feeders, and soon strip the foliage from a plant; but being so conspicuous they can be readily got rid of by hand picking. When growth is completed, the caterpillars burrow into the earth and form a cell in which they transform to a dark brown chrysalis, which has attached to the head and under side of the thorax a projection resembling the handle of a jug (Fig. 46) and containing the enormously long sucking tube with which the moth is provided. Usually it remains buried in the ground until spring, but occasionally some of the moths come out in the autumn if the weather should be warm. They are large, handsome, swiftly flying creatures, ashen-gray in color with a variety of paler and darker lines and markings; the abdomen is ornamented with five large orange spots on each side which give the insect a very characteristic appearance. These Tomato worms have often been supposed to be poisonous, and many marvellous tales have been told of their deadly stings and bites; they are, however, quite incapable of either stinging or biting, and may be handled without the least danger.

The CORN EAR-WORM (*Heliothis armiger*), which has been described above, frequently attacks green tomatoes before they are fully grown and bores large holes which utterly destroy the fruit. It also feeds on tobacco, eating into the unripe seed capsules and devouring the contents. In the case of tomatoes the only plan seems to be to cut off and destroy all the infested green fruit. Where tobacco is extensively grown, if there should be an annual attack by these caterpillars, it would be advisable to grow a strip of corn as a "trap-crop" along the sides of the field; the moths would lay their eggs on the young ears of corn in preference to the tobacco plant, and these could be gathered and burnt or fed to pigs before the worms attained to maturity.

TURNIPS.

Turnips are attacked by several of the insects already described as enemies of the cabbage, viz., the Zebra Caterpillar, the Diamond-back Moth, the Cabbage Maggot, and the same species of Plant-louse (*Aphis*). The last mentioned insect has been more complained of recently by turnip growers than any other pest; its ravages in late summer and autumn of 1908 were widespread over the province, due to the pro-

longed dry, warm weather which was favorable to their increase, and in many cases whole fields were rendered worthless. The usual remedies, kerosene emulsion and strong soapsuds, were found effective when applied in time; but in most cases the attack was not noticed till the damage was beyond repair. Much may be accomplished by keeping a sharp look-out for the colonies of plant-lice when hoeing is being done; an affected plant should be at once cut out and the lice crushed under foot; early measures of this kind will prevent a serious infestation later on.

The TURNIP FLEA-BEETLE (*Phyllotreta vittata*) differs from our other species in having a wavy yellowish stripe down each side of the wing covers, but its habits are much the same as those of the rest of

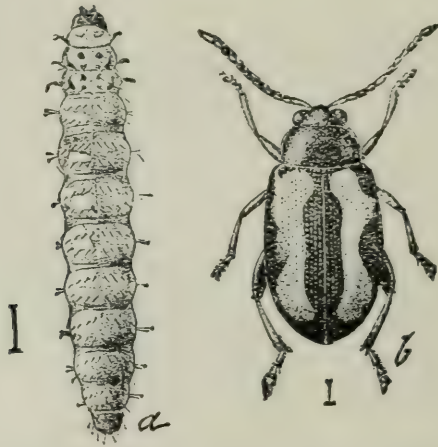


Fig. 47. The Turnip Flea-beetle and larva—greatly enlarged.

the family. Its attacks on the young plants when they first come up are often very serious and prevent the growth of a large proportion of the crop, necessitating a resowing. As the first brood of beetles disappears toward the end of June it has been found that turnips sown during the third week of that month escape attack, and produce as good a crop as those sown earlier. When the beetles are observed to be attacking the young plants they may be got rid of by dusting with Paris green and land plaster, one pound of the poison to twenty of the plaster; this should be done when the plants are moist with dew in the early morning. A condition of the soil which induces rapid and vigorous growth is of great importance, as it enables the young plants to get beyond the danger point before much injury has been sustained.

Fungus Diseases of Vegetables.

BY J. W. EASTHAM AND J. E. HOWITT.

It is important that those having to deal with fungus diseases should understand the cause of such disease, in order that they may apply intelligently remedies for their control. Fungus diseases are caused by a low group of minute plants known as Fungi. These plants, unlike ordinary flowering plants, have no green coloring matter and are entirely unable to manufacture their own food. All their nourishment therefore must be obtained from decaying animal or vegetable remains or from living animals or plants. Those Fungi which derive their nourishment from living plants in so doing injure them in various ways, and thus give rise to what are known as fungus diseases.

The bodies of Fungi which cause plant diseases are usually very simple, consisting of fine delicate threads or tubes (hyphæ), some of which become modified and produce reproductive structures, termed spores, which may be considered similar to the seeds of flowering plants. Sometimes the fungus threads live upon the surface of the plants and obtain their nourishment by sending down little suckers (haustoria) into the cells below; most frequently, however, they live within the plants, either in or between the cells. Two kinds of spores are frequently produced, thin-walled summer spores which spread the disease during the summer, and thick-walled resting or winter spores which carry the disease over the winter. Spores are scattered by various agencies, chief among which are wind, water and insects. On coming in contact with a suitable host plant they send out little threads which enter the plant through the breathing-pores on the leaves, through the skin, or through wounds. Once within, the little threads grow very rapidly, drawing their nourishment from the cells of the host plant and setting up a diseased condition.

Generally speaking, in combating fungus diseases methods of prevention only are practicable, as once a fungus is within a plant nothing can be done to destroy it. Care should be taken to keep the crops in a healthy, growing condition and free from injury by insects. Unthrifty plants and those attacked by insects are more liable to fungus diseases than healthy ones. Rotation of crops should be practised so that the winter spores left in the soil may not infect next season's crop. Weeds should be destroyed as they frequently harbor fungi. Diseased crop refuse should be burnt and not thrown on the manure heap. Fresh manure should be avoided as it frequently contains living spores of parasitic fungi. Intelligent and thorough spraying with Bordeaux or other fungicides will do much to prevent the spread of fungus diseases.

ASPARAGUS.

RUST (*Puccinia asparagi*). This disease is very common and is familiar to every grower of asparagus. It has three distinct stages. The first is known as the "cluster-cup" stage or the spring form. In this stage the spores are produced in cup-shaped pustules, which are grouped in oval clusters and are orange-yellow when mature. This stage is seldom noticed by asparagus growers. The second or summer stage

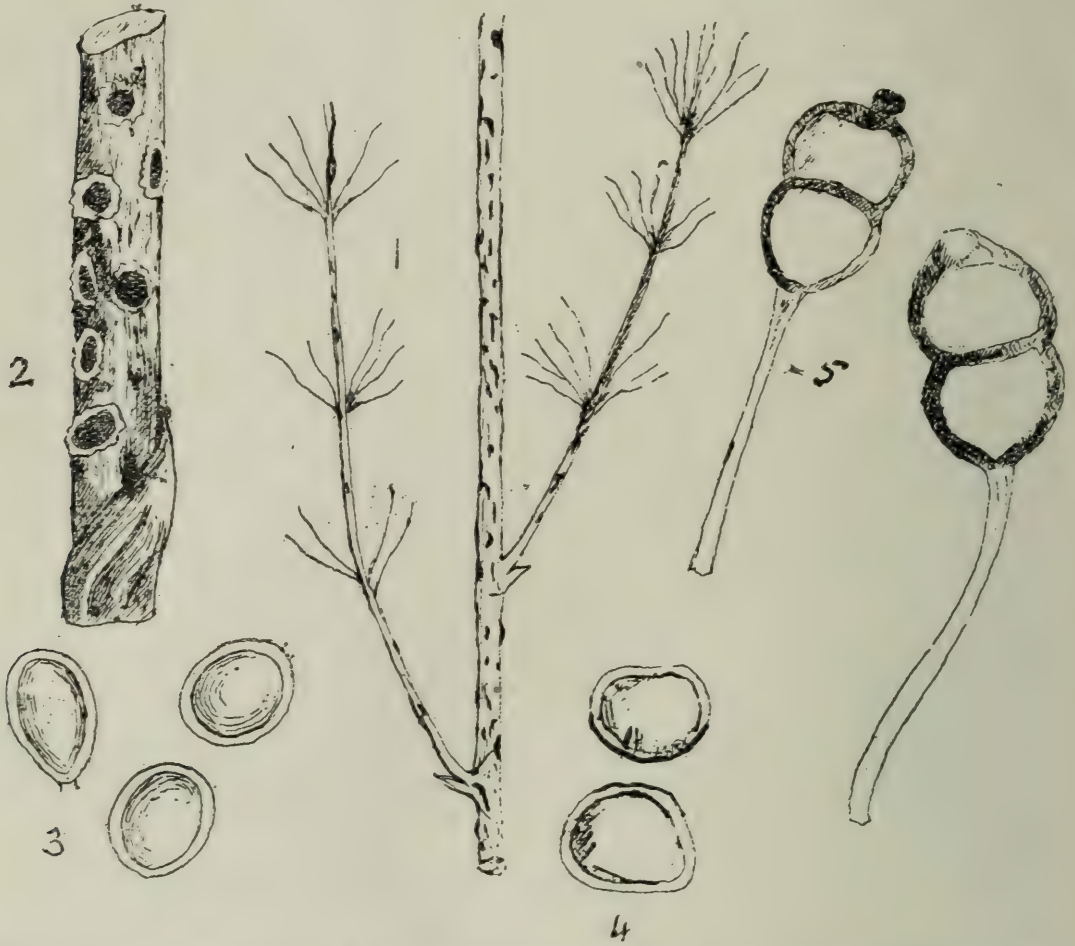


Fig. 48. Asparagus Rust. 1, attacked stem showing spore clusters; 2, cluster-cup form; 3, spores from cluster-cup; 4, spores from summer stage (uredo spores); 5, resting or winter spores (teleuto spores).

is the one usually first noticed by the growers, and called by them the "red rust" on account of the elongated reddish-brown pustules which are seen breaking through the skin of the stem. In these pustules reddish, one-celled spores are produced, known as uredospores. It is in the summer or "red rust" stage that the disease spreads most rapidly and appears to do the greatest amount of harm. Towards fall, or whenever the vitality of the asparagus plants is reduced, the third and final stage

known as the "black rust" or winter stage appears, due to the fact that the red spores in the pustules are replaced by dark brown, two-celled, thick-walled spores known as teleutospores. These germinate in the spring and produce the first stage again.

Treatment: Rust may be largely controlled by spraying with resin-Bordeaux from July to September at intervals of ten days or two weeks. This is a difficult and rather costly undertaking and will hardly pay

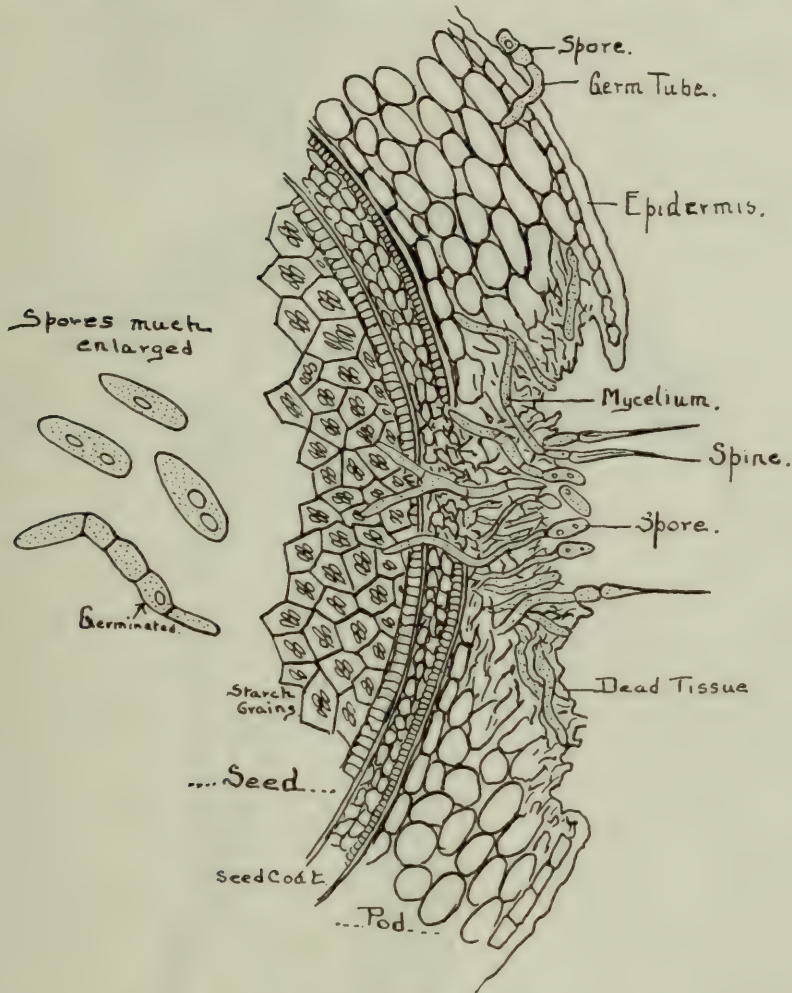


Fig. 49. Bean Anthracnose. The right-hand figure shows a section taken through a spot on pod and the seed beneath. Note how the hyphae in the "pod-spot" are penetrating into the cells of the seed. On the left are shown a number of enlarged spores.—(After Whetzel.)

except on large areas. Dusting with flowers of sulphur has given good results. Cutting and burning all the diseased stems in the fall will help to keep the rust in check. Rust resistant varieties should be planted.

BEANS.

ANTHRACNOSE OR POD-SPOT (*Colletotrichum lindemuthianum*). This is the commonest and worst disease to which beans are liable. It attacks

stem, leaves, pods and seeds, beginning with the first leaves of the seedling plant. The disease appears as round, rusty or black, sunken spots. In the centre of each of these is produced a mass of spores which



Fig. 50. Bean Anthracnose. Badly attacked pod, showing the dark spots characteristic of the disease.

are embedded in a gummy substance. This substance, when dry, keeps the spores attached to the spot but, when moistened by rain or heavy dew, it becomes soft and allows the spores to be scattered.

The spots are most conspicuous on the pods, and hence the disease is sometimes termed "pod-spot." The fungus working in the diseased areas finally penetrates through the wall of the pod into the seeds. Here it remains in a more or less inactive condition until the seed is sown when it becomes active and forms the starting point of the disease. The seedlings from such attacked seeds will often show the spots on the seed-leaves. Once spores begin to be formed the disease spreads rapidly.

Treatment: Since the disease originates with infected seed, the most important point is to secure, if possible, clean seed. This can be



Fig. 51. Leaf of Beet attacked by Leaf-spot Fungus (*Cercospora beticola*).

obtained by gathering it from pods which are free from spots, the disease, as far as is known, only infecting the seed through the pod. Although seeds that are badly attacked may be readily recognised by their discolored areas, hand-sorting of such seed previous to sowing is practically valueless, as a large percentage of the apparently healthy ones will contain the fungus. Treating the seed with formalin is also useless. Care should be taken not to work amongst the plants when they are wet with rain or dew since it is at this time that the spores are

ready to be distributed and each spore may start a new spot. Spraying with Bordeaux mixture appears to be capable of controlling the disease provided it can be done thoroughly enough. This, however, is only possible when done by hand on garden crops. Under ordinary field conditions it is of little value.

RUST (*Uromyces appendiculatus*). This appears as small, round, rusty brown, raised spots on the surface of the leaves. Leaf-stalks and pods may also be affected. Later the spots darken in color owing to the formation of a different kind of spore (teleutospore) which serves to carry the fungus over the winter.

Treatment: Burn the remains of diseased plants. Some varieties are found to be more resistant than others, and where possible these should be selected. Early spraying with Bordeaux mixture will diminish the injury. The disease, however, is not often of a serious nature.

BEET.

LEAF SPOT (*Cercospora beticola*). This occasionally causes serious injury, though garden varieties appear to be more resistant than the sugar beet. The disease causes small brown spots with purplish margins, which are scattered irregularly over the leaves. Later, these spots become ashey gray in color. When very numerous the leaf-tissue is to a large extent destroyed and the value of the leaf to the plant correspondingly lessened.

Treatment: Spray with resin-Bordeaux at intervals of 10 to 14 days, beginning about the middle of July. The disease is seldom bad enough to require treatment.

CABBAGE AND CAULIFLOWER.

CLUB ROOT (*Plasmodiophora brassicæ*). This disease attacks cabbage, cauliflower, turnips, radish and other members of the Cruciferae. It is caused by a slime-fungus. Plants attacked are noticed to markedly flag or wilt, and if their roots are examined irregular thickenings and knob-like swellings are found upon them. These often reach the size of a man's fist. The tops of affected plants develop very slowly, cauliflowers and cabbage attacked forming little or no head. The plants are often completely killed, due to the fact that the swellings on the root prevent the proper absorption of water. The cells of the swellings are unusually large and filled with brownish, irregular masses of protoplasm. Each such mass represents the vegetative body of a single organism. The vegetative bodies feed and grow at the expense of the cell contents. They pass from cell to cell and when the food supply is exhausted each one divides into a large number of spores, which, when the swellings decay, are set free into the soil. Naked, motile pieces of protoplasm emerge from the spores when they germinate. These it is thought enter

the plants through the root hairs. This disease may remain in the soil for several years. It is chiefly spread in manure and by means of infected seedling stock.

Treatment: *"Practise crop rotation. Set out only healthy plants. Do not use manure containing cabbage refuse. If necessary to use infested land apply good stone lime, 2 to 5 tons per acre. Apply at least as early as the autumn before planting, two to four years is better. Lime the seed bed in the same manner." Burn all refuse from diseased crop. Do not use manure from stock fed upon clubbed roots. Keep down weeds belonging to the Cruciferæ; they may harbor the disease.

BLACK ROT (*Pseudomonas campestris*). This is a bacterial disease which attacks cabbage, cauliflower, rape, and Swede turnip. The bacteria get into the veins of the leaves clogging and turning them black. The lower leaves are usually first affected. The leaves drop and no heads are formed. This disease is especially bad on low damp soils.

Treatment: Avoid low, damp soils, practise rotation of crops, soak seed 15 minutes in a solution made by dissolving one pint of formalin in thirty gallons of water.

SOFT ROT (*Bacillus oleraceæ*). This is another bacterial disease of cabbage and cauliflower. (See O.A.C. Bulletin 136.)

CELERY.

CERCOSPORA LEAF-BLIGHT or **EARLY BLIGHT** (*Cercospora apii*). This appears early in the season often showing in the seed-bed. It is characterised by more or less circular spots, greyish green in color at first, then becoming brown and later ashy. Separate spots generally have a well marked border. When numerous they run together into irregular patches. This disease disappears with the coming of the cool nights of autumn when it may be followed by the late blight.

Treatment: Spray five to eight times during the season beginning whilst the plants are still in the seed-bed. Bordeaux may be used for the first application. Ammoniacal Copper Carbonate should be employed for the rest. Refuse from diseased crop should be destroyed.

SEPTORIA LEAF-BLIGHT or **LATE BLIGHT** (*Septoria petroselini*, var. *apii*). This appears later in the season than the last. The spots produced are usually more irregular and tawny in color. Little black fruiting bodies develop in the spots on both sides of the leaf. The disease continues active until the plants are lifted and may subsequently cause serious rotting in storage. Neither this pest nor the last seems to give much trouble on shady, well-drained land.

Treatment: Spraying with ammoniacal copper carbonate, continued till the plants are lifted. Diseased leaves should be stripped off before the plants are placed in storage. Remains of diseased crop should be destroyed.

*Cornell Bulletin 252.

CORN.

CORN SMUT (*Ustilago Zeæ*). This is an exceedingly common disease, familiar to every grower of corn. On stalks, leaves, staminate tassels, and ears appear peculiar growths, usually spoken of as "boils." These growths are white and polished in the early stage but become darker as they mature. They are filled with black spores which produce

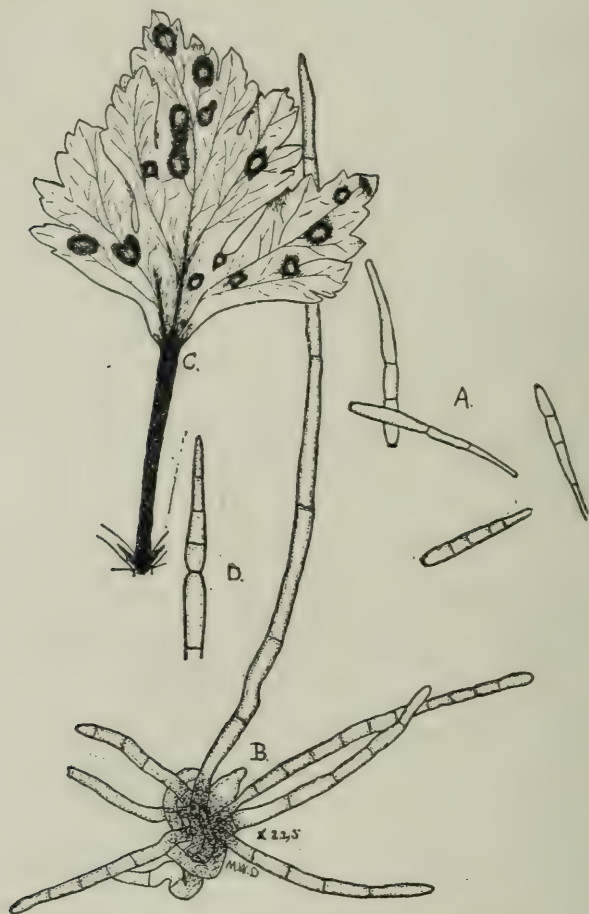


Fig. 52. *Leaf Spot or "Early Blight" of Celery.* a, Spores; b, Hyphae projecting through a breathing-pore of the leaf into the air; c, a diseased leaf showing the spots caused by the parasite; d, Spore still attached to parent hyphal (conidiophore).

great numbers of secondary spores. These are spread by the wind or other agencies and may infect any of the tender growing tissue of the corn plants. Thus the disease is spread during the growing season. Some of the spores winter over in the soil or in manure and start the disease afresh the next season.

Treatment: Remove and burn all the smut growths as soon as they appear; avoid fresh manure; practise rotation of crops. Seed treatment is not effective.

RUST (*Puccinia sorghi*). This disease is seldom serious. Attacked leaves show elongated reddish or blackish pustules on both surfaces.

CUCUMBER.

DOWNY MILDEW or BLIGHT (*Plasmopora cubensis*). This fungus attacks cucumber, melon, squash and pumpkin plants, damaging, and in bad cases, destroying the foliage. The disease appears as yellow spots of indefinite outline. If the weather conditions are favorable these rapidly enlarge, and finally the entire leaf withers up.

Treatment: Spray with Bordeaux, beginning when the plants begin to run and repeating every ten to fourteen days throughout the season. This treatment, though valuable for keeping the disease in check on cucumbers, has not been found very effective with melons.

WILT (*Bacillus tracheiphilus*). This attacks the same plants as the last disease. It is caused by a minute organism—a bacillus—which multiplies with great rapidity in the sap-vessels of the leaf and stem, breaking them down and preventing the flow of sap. As a consequence the plant wilts and rapidly dies. If an attacked stem or leaf-stalk be pulled apart, a sticky fluid exudes from the broken surface which may be drawn out into long threads.

Treatment: The disease is largely distributed by cucumber beetles. These should therefore be kept down by the means recommended under insect pests of the cucumber. Remains of diseased plants should be burned.

LETTUCE.

The following fungus diseases are usually only of importance in greenhouse cultivation.

“Drop” (*Sclerotinia Libertiana*). This is the most serious disease to which lettuces are liable. It shows itself in a rotting of the stem followed by sudden and total collapse of the plant, hence the name “drop.” The greatest loss occurs when the plants are just about full grown. The fungus appears to spread almost entirely by the mycelium or tissue of the fungus growing through the soil. Dense, compact portions of this mycelium form little masses (sclerotia) by means of which it is enabled to pass over the unfavorable conditions intervening between successive crops.

Treatment: Sterilizing the upper layers of the soil by applications of boiling water before sowing the seed will much reduce the loss. Covering the surface with sterilized sand or earth has been found to materially lessen the disease, the effect being proportional to the thickness of the layer added. If these treatments cannot be applied, the only alternative is to change the soil for each crop of lettuce.

Two other fungous diseases, the Downy Mildew (*Bremia lactuæ*) and the Grey Rot (*Botrytis vulgaris*), may attack lettuce but are not

serious enemies when the crop is properly managed. In this connection it is important to water the plants in some way that will not wet the foliage, especially after the plants are half grown. To this end sub-irrigation has been successfully employed.

MELON AND SQUASH.

See Cucumber.

ONION.

ONION BLIGHT or MILDEW (*Peronospora Schleideniana*). This is the commonest disease of the onion, and it frequently decreases very materially the onion crop by destroying the leaves and thus reducing to a marked extent the size of the bulbs. It usually first makes its appearance in late June or July. Attacked leaves first show peculiar violet tinted areas, due to the fact that these areas are covered with the fuzzy spore-bearing portions of the fungus. The diseased leaves very soon become pale or yellowish in spots and collapse and break down. If examined they are seen to be more or less covered with the spore-bearing part of the fungus which gives the surface of the leaves a furry appearance. In severe attacks all the leaves in field or patch are very soon destroyed. They are often, however, quickly replaced by a new crop which in turn is generally destroyed by the disease and from this second attack the onions do not usually recover. Two kinds of spores are produced by the fungus, viz., thin-walled summer spores borne on the minute branched spore-bearing parts of the fungus covering the surface of the attacked leaves, and thick-walled resting spores (oospores) formed in the tissues of the dead leaves. The summer spores are freely scattered by the wind during the summer and new leaves thus become infected. In this way the disease spreads very rapidly, especially during damp, muggy weather. Dead leaves containing the thick-walled resting spores lie on the ground during the winter, and in the spring the spores germinate and give rise to the disease if onions are again planted on the same ground.

Treatment: Once the leaves are attacked nothing can be done to save them, though the disease may be prevented from spreading and the second crop of leaves saved by thorough and frequent spraying with Bordeaux. Prevention therefore is the only treatment. Spray thoroughly with resin-Bordeaux, beginning about the end of June and continuing throughout the season. Rake up and burn the diseased tops, as by so doing many of the resting spores will be destroyed. Practise rotation of crops, as the disease is carried over the winter by the resting spores on the ground, and it is believed that they retain their vitality for two or three years. Plant onions on well drained land over which there is free circulation of air.

ONION SMUT (*Urocystis cepulæ*). This disease attacks onions grown from seed. It destroys many of the seedlings shortly after they appear above the ground. The diseased seedlings which are not completely killed in the early stage are so severely injured that they die later or produce small and misshapen bulbs. The disease also appears on mature bulbs in the fall. Affected leaves are enlarged and often distorted and dark in color with black streaks. If they are broken they are found to be filled with a black, powdery mass which is composed of the spores of the fungus. Black masses of these smut spores are also found on the bulbs. The spores winter over in the soil, hence the danger of planting onions on smut infested soil. The disease is not, as generally supposed, disseminated to any extent in the onion seed. It may, however, be carried long distances on the bulbs.

Treatment: (1) Transplanting. If the soil is smut infested grow the seedlings on smut free soil, then transplant. This is a certain preventive, but it involves considerable labor. (2) Rotation of crops will reduce considerably the amount of the smut.

(3) Drill into the rows when planting seed 100 lbs. sulphur mixed with 50 lbs. of lime, per acre. Such applications have been found to greatly reduce the amount of the smut. Lime and sulphur sown broadcast are not effective.

BLACK MOULD (*Macrosporium parasiticum*). This fungus generally follows the Downy Mildew, causing the dead and dying leaves to become blackened and covered with a thick black fungus growth. As far as is known it does not attack healthy leaves, and therefore its appearance on dead and dying tops should not cause any alarm.

PEAS.

BLIGHT or LEAF SPOT (*Ascochyta pisi*). This attacks stem, leaves, pods and seeds, originating with infected seed (compare Bean Anthracnose). The stems of attacked plants may show discolored areas of dead tissue sometimes extending completely round them and destroying the shoot. The stem attack is generally worst near the ground. Attacked leaves show round or oval discolored spots from $\frac{1}{8}$ to $\frac{1}{2}$ an inch in diameter. On the pods the disease appears as sunken spots much like those of bean anthracnose but pale in color. The fungus in these spots works through into the underlying seeds and infects them. In the discolored areas on the various parts of the plant the fruiting bodies (pycnidia) will be found as yellowish raised points.

Treatment: Seed free from the disease should be sown. This may be obtained by selecting it from healthy pods. Spraying with Bordeaux mixture, beginning when the plants are from two to four inches high, and repeating at intervals of five to ten days according to the weather, will do much towards controlling the disease. Though such treatment may not be worth while for the sake of the general crop, it is advisable

to apply it on a small scale to plants set apart for seed production, since healthy pods bear healthy seeds and healthy seeds will produce a clean crop the following year.

POWDERY MILDEW (*Erysiphe polygoni*). This usually appears late in the season. The fungus is of superficial habit, and forms a whitish or grayish coating which may occur on any part of the plant above ground. Later, minute black fruiting bodies are to be found scattered over the mildewed surface.

Treatment: Since the fungus grows on the surface of the plant it is killed by application of Bordeaux mixture.

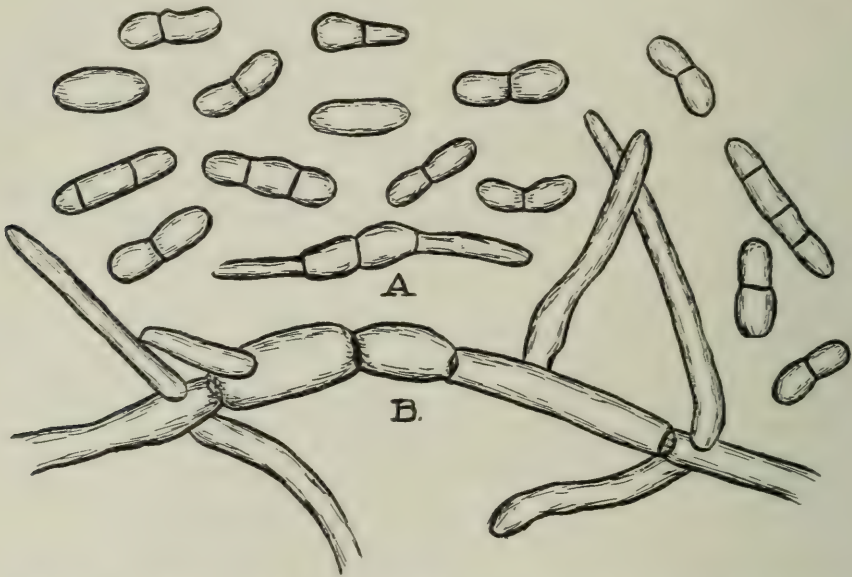


Fig. 53. Pea Blight Fungus. A, spores; most of these are 2-celled when mature. B, a portion of the mycelium.—(After Selby.)

POTATO.

LATE BLIGHT or DOWNY MILDEW (*Phytophthora infestans*). This is the most destructive disease of the potato. It causes more or less damage every year, and in seasons when weather conditions are suitable to its growth and development the loss frequently exceeds fifty per cent. of the crop. The effects of the disease are not noticed until late summer. The first indication of the disease is the appearance of small brown patches upon the leaves, most frequently at the margins. These soon enlarge, become black and the leaf curls. In severe attacks the leaves and stems become black and decayed in a very short time emitting a very disagreeable yet characteristic odor. If the brown spots on the under side of the leaves are examined when the disease is active, a delicate white mildewy growth will be observed especially around the margins. The disease also manifests itself by producing brown, dead patches just

below the skin of the tubers. A subsequent rotting of the tubers often takes place, which is now generally supposed to be due to the spread of the disease within them. During the summer months numerous small spores are produced on the lower surface of the diseased spots. These are readily dispersed by wind and moisture, and thus the disease soon becomes spread over an entire field. So far as is known the disease

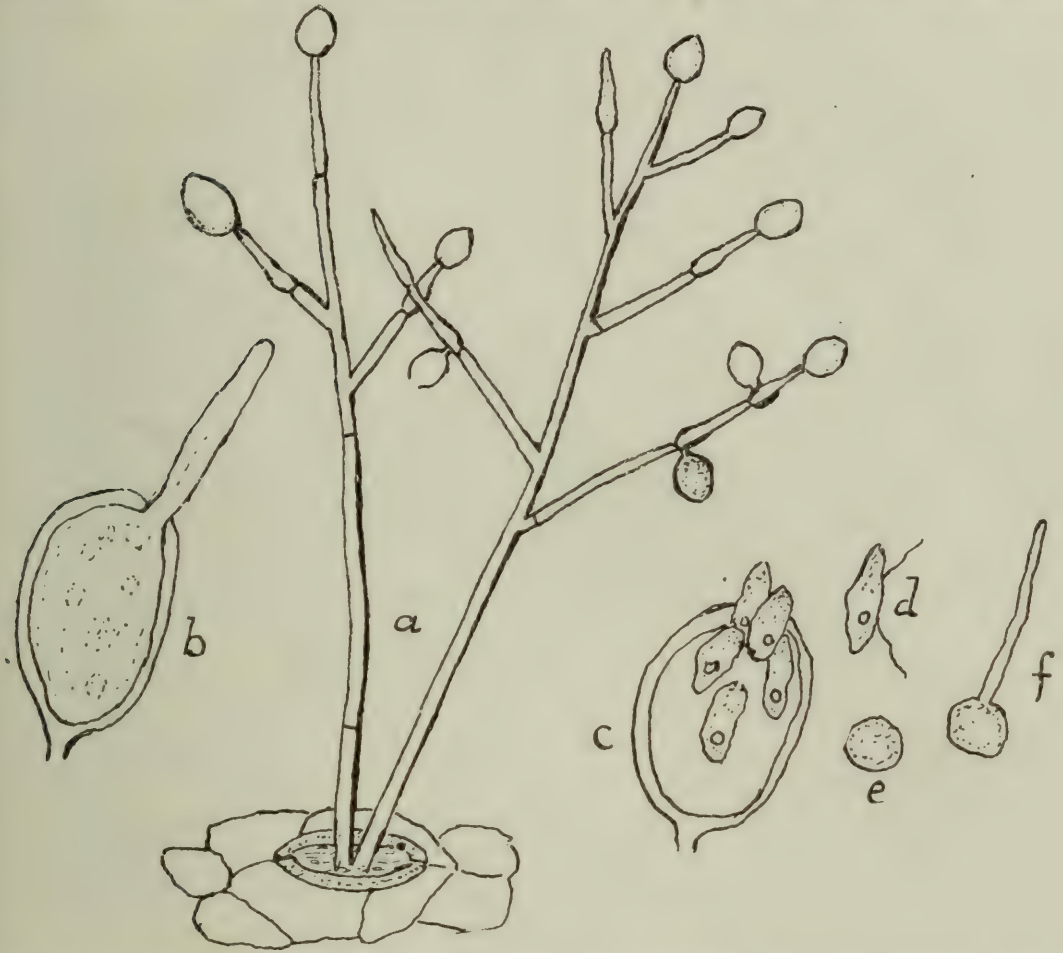


Fig. 54. Late Blight. *a*, Hyphae protruded through a breathing-pore of the leaf and bearing spores; *b*, a spore (conidium) germinating; *c*, a spore-case (sporangium) the contents of which have divided up to form a number of active swimming spores (zoospores); *d*, a zoospore with its two whips; *e*, the same after withdrawing the whips; *f*, the same germinating.

is carried over the winter only as the fungus threads within the attacked tubers. Thus the source of new infection is supposed to be from stored potatoes used for seed and from old tubers left on the ground. On these it is supposed that a new crop of spores is produced, which find their way on to the potato leaves.

Treatment: Spray with Bordeaux. Begin spraying about July 10th, and keep the vines covered with Bordeaux until danger of infection is

over, which will be about the middle of September. It will require from 4 to 6 sprayings to accomplish this. Plant quickly maturing varieties and avoid those which are most susceptible to the disease. Avoid wet soils, if possible. To prevent the rotting of the tubers: delay digging ten days until the tops dry. Do not pile and cover with diseased tops. Hill or mold up 5 inches deep.



Fig. 55. Late Blight.



Fig. 56. Early Blight.

EARLY BLIGHT or LEAF SPOT DISEASE (*Alternaria solani*). This disease sometimes appears when the plants are from 6 to 8 inches high, but is most abundant about the time the tubers are forming. In severe cases the foliage is badly damaged and the tubers remain small. Unhealthy plants and those attacked by the flea-beetle suffer most from this disease. Small scattered grayish brown circular spots are first observed upon the leaves. These take on a minutely velvety appearance, and gradually become larger, and run into each other, until in some cases half the leaf may become brown and curled. As the spots enlarge faint

concentric rings appear on them described as "target brand" markings. It is thought that the disease passes the winter in a resting condition in the dead leaves and that the spores may winter over in the soil.

Treatment: Spray with Bordeaux and Paris green when the plants are three or four inches high, and repeat every two weeks through June and July. This treatment will control both the fungus and the flea-beetles. Clean up and burn the diseased tops.

POTATO SCAB (*Oospora scabies*). This disease causes the familiar blackened, pocket-like cavities and roughened corky spots on the skin of the tubers. On the surface of these spots during their development are produced numerous minute spores which remain attached to the potatoes or in the soil over the winter. It is known that the spores may remain in the soil for several years and then produce the disease again. Alkali fertilizers are known to produce conditions favorable for the development of this disease.

Treatment: Rotation of crops. Avoid alkali fertilizers such as lime and wood ashes. Do not use fresh manure from stock fed on scabby potatoes. For seed select tubers which are free from scab, and disinfect them by soaking them (before they are cut) for two hours in a solution made by adding one-half pint of commercial formalin to 15 gallons of water. Disinfect all bags, baskets, implements, etc., which have been used in handling scabby potatoes.

WET ROT (*Bacillus* sp.) A common bacterial disease of potatoes producing soft rot.

RADISH.

WHITE RUST (*Albugo candida*). This attacks many kinds of plants, wild and cultivated, belonging to the Mustard family (*Cruciferae*). It is very common on Shepherd's Purse. The disease appears as white shining spots and patches on the leaves and stalks. At these places large numbers of summer spores are produced. Later, resting spores are formed in the attacked tissues and these carry the disease over the winter if the affected leaves are allowed to lie on the ground. Attacked plants may be stunted and deformed but the disease can hardly be described as a serious one.

Treatment: Pull and burn attacked plants. Keep down such weeds as Shepherd's Purse and Mustard which are the natural hosts of the pest.

TOMATO.

LEAF SPOT (*Septoria lycopersici*). This is the most destructive disease attacking the leaves and stems of tomatoes, and it is very hard to control. Small grayish-brown, angular spots containing minute black fruiting bodies appear upon the leaves and stems. The lower ones are first attacked and the disease spreads upwards, often almost defoliating

the plants. Many growers report that this disease is worst on high, dry, gravelly or sandy soils. It is carried over the winter in the diseased stems and leaves.

Treatment: Spray with Bordeaux a week after transplanting and repeat at intervals of ten days or two weeks. It is often advisable to stake and tie up the plants for greater convenience in spraying. Pinch-

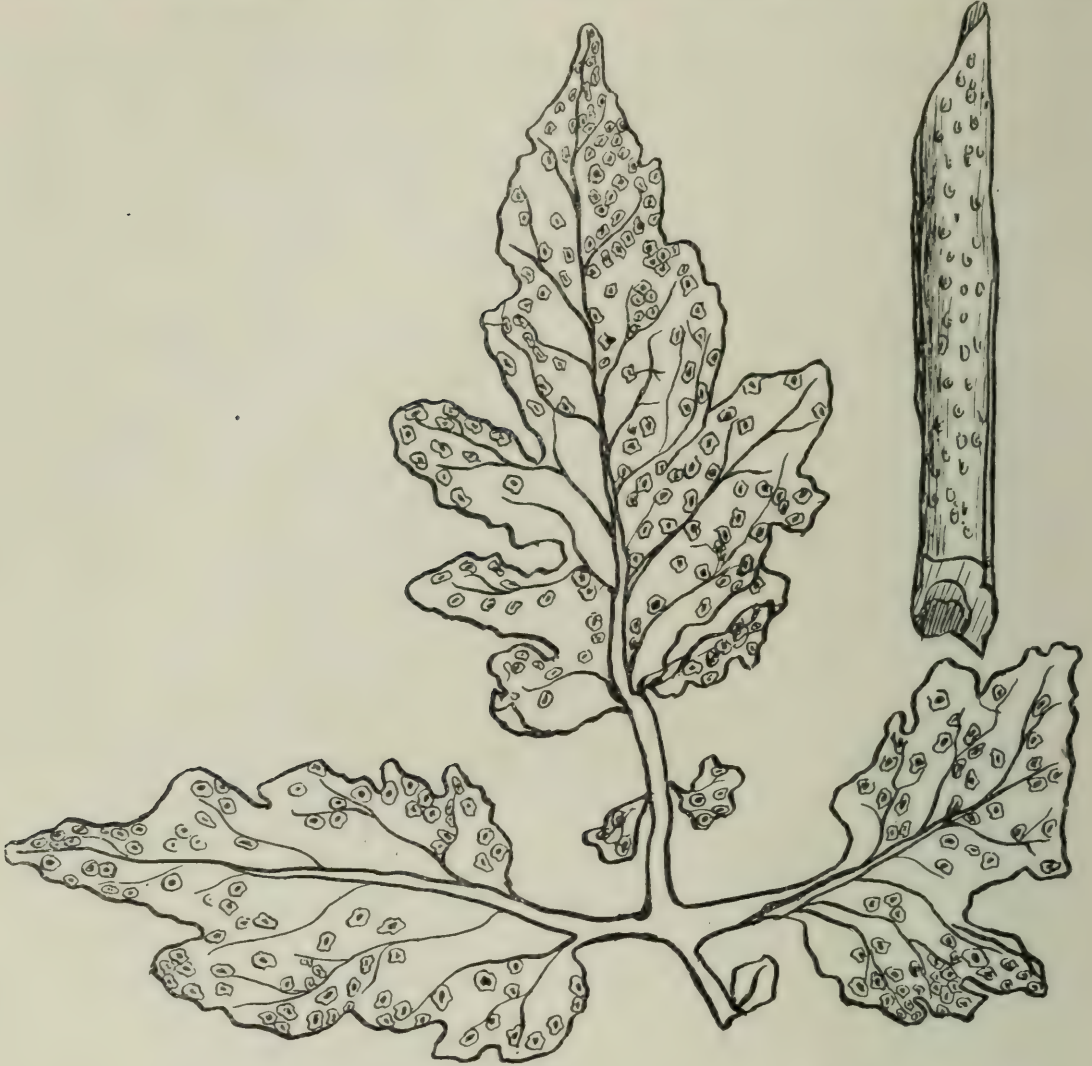


Fig. 57. Leaf-spot of Tomato. Attacked leaves and stem. (From Ohio Bull. 73.)

ing off the lower leaves which touch the ground when the plants are set out is also recommended. The diseased tops should be raked up and burnt.

BLACK ROT (*Macrosporium tomato*). This fungus attacks the stems, leaves and fruit. It is by the destruction of the fruit, however, that it causes the most serious loss. Roundish black velvety spots appear on the blossom end of the tomatoes. These increase in size and sometimes

involve the whole fruit. On the surface of the diseased spots dark colored, many-celled, club-shaped spores are produced.

Treatment: Spray with Bordeaux, beginning when the flowers open, and repeat at intervals of ten days or two weeks. Remove and destroy diseased fruits. Burn the diseased tops.

SCAB (*Cladosporium fulvum*). Olive brown, felt-like areas occur on the under side of the leaves and brown discolorations on the upper surface. In severe cases the leaves turn black, shrivel up and die. Tawny-colored, two-celled spores are produced on the clustered stalks of the fungus on the under surface.

Treatment: Spray with Bordeaux early and repeat at intervals of ten days or two weeks.



Fig. 58. Black Rot on Tomato.

TURNIP.

See Cabbage.

DAMPING-OFF OF SEEDLINGS.

The seedlings of many plants are liable to be attacked by a disease which weakens the stem at or near the ground, causing the plant to fall over and ultimately die. In most cases this is probably due to the fungus *Pythium de Baryanum*. As the name of the disease indicates, it is usually associated with too moist a condition of the soil or atmosphere. Cruciferous seedlings, e.g., radish, cress, seem especially liable to it. If an attacked seedling be examined it will be found that the stem tissue is shrunken and collapsed at the place where it has fallen over, and at

this point the parasite will likely be seen growing out as a fine mould. Two kinds of spores are produced, the one germinating immediately and serving for the rapid spread of the disease, the other a resting spore.

Treatment: For a seed-bed secure well drained soil not previously infested with the disease. Avoid thick sowing, shade, and over watering. Attacked plants should be removed as soon as noticed, together with the adjacent soil. This stops the formation of spores and prevents the hyphæ growing from the attacked plants over the intervening soil to new plants.

INSECTICIDES.

PARIS GREEN AND BORDEAUX MIXTURE.

Four pounds of fresh lime, 4 pounds of bluestone, and 4 ounces of Paris green, thoroughly mixed in 40 gallons of water. In all cases where spraying with Paris green is recommended in the foregoing pages it is advisable to add the bluestone (or Bordeaux mixture) in order to counteract fungus diseases at the same time as the insects are destroyed. The bluestone (copper sulphate) should be dissolved by suspending it in a wooden vessel containing 4 or 5 gallons of water, and the lime slaked in another vessel; if lumpy, the lime should be strained through coarse sacking. Pour the bluestone solution into a barrel and half fill with water; dilute the slaked lime to half a barrel and mix the two together. The Paris green should be made into a paste with warm water, poured into the barrel and stirred thoroughly. The mixture is then ready for use. The addition of the lime prevents the poison from scorching the foliage.

ARSENATE OF LEAD.

Arsenate of soda	10 ounces.
Acetate of lead	24 ounces.
Water	150-200 gallons.

"The arsenate of soda and the acetate of lead (sugar of lead) should be dissolved separately and then poured into a tank containing the required amount of water. A white precipitate of lead arsenate is immediately formed, and when thoroughly stirred, is ready for spraying. Its finely divided condition keeps it in suspension for hours and thus simplifies the work of spraying. The preparation may be used several times stronger without the least danger of scorching the most delicate plants. When sprayed upon the foliage it forms a coating which adheres so firmly that it is but little affected by ordinary rains." (Bulletin 154, Harcourt and Fulmer.)

KEROSENE EMULSION.

The following is the formula recommended by Dr. Fletcher (Central Experimental Farm, Bulletin No. 52):

Kerosene (coal oil)	2 gallons.
Rain water	1 gallon.
Soap	$\frac{1}{2}$ pound.

Boil the soap in water till all is dissolved; then, while boiling hot, turn it into the kerosene and churn the mixture constantly and forcibly with a syringe or force pump for five minutes, when it will be of a smooth, creamy nature. If the emulsion is perfect, it will adhere to the surface of glass without oiliness. As it cools it thickens into a jelly-like mass. This gives the stock emulsion, which must be diluted with nine times its measure of warm water before using on vegetation. The above quantity of three gallons of emulsion will make 30 gallons of wash.

Kerosene emulsion may also be made conveniently by using an equal amount of sour milk instead of the soap and water in the above formula, and churning for the same time to get the stock emulsion.

Another method is to use lime, which will hold the kerosene in suspension, or the following, where lime cannot be obtained:

The requisite amount of kerosene is placed in a dry vessel and flour added in the proportion of 8 ounces to one quart of kerosene. It is then thoroughly stirred and two gallons of water added for every quart of kerosene; the whole is then vigorously churned for from two to four minutes, and the emulsion is ready for use. It has been found that by scalding the flour before adding the kerosene, an excellent emulsion which does not separate in the least after standing for a week, can be prepared with 2 ounces of flour, by mixing the resulting paste with one quart of kerosene and emulsifying with two gallons of water.

TOBACCO WASH (for destroying Aphis).

Soak 4 pounds of tobacco waste in 9 gallons of hot water for four or five hours (in cold water for four or five days); dissolve one pound of whale-oil soap in one gallon of hot water; strain the decoction into the dissolved soap and apply with a spray pump as forcibly as possible.

SOAP WASHES.

Dissolve one pound of whale-oil soap in four gallons of warm water for black or brown Aphis, and one pound in six gallons for green Aphis.

Another remedy for Aphis is the following: Boil 8 pounds of quassia chips in 8 gallons of water for an hour, dissolve 7 pounds of whaleoil soap in hot water; strain the quassia decoction and mix with the soap solution; then dilute to make 100 gallons. Spray forcibly while hot; this will kill the plant-lice and not injure the plants.

COOK'S CARBOLIC SOAP WASH.

Hard soap, one pound, or soft soap.....	1 quart.
Crude carbolic acid	1 pint.
Water (boiling)	1 gallon.

Dissolve the soap in the boiling water ; while still hot add the carbolic acid ; emulsify thoroughly. This is the stock solution. For use, dilute with 30 to 50 times its bulk of water. Very effective against root-maggots of cabbage, radish and onion.

HELLEBORE.

White hellebore (fresh)	1 ounce.
Water	2 gallons.

PYRETHRUM, OR INSECT POWDER.

Pyrethrum powder (fresh)	1 ounce.
Water	3 gallons.

Or,

Pyrethrum powder	1 ounce.
Flour (cheap)	5 ounces.

Mix thoroughly, allow to stand over night in a closed tin box, then dust on plants through cheese-cloth.

THE POISONED BRAN MASH.

For Cutworms.

Mix half a pound of Paris green in 50 lbs. of bran (the proportion for larger or smaller quantities is 1 to 100) ; the poison should be added to the dry bran little by little and stirred all the time till the whole is tinged with the green color, then add water sweetened with sugar, or molasses, till the mixture is sufficiently moistened to crumble nicely through the fingers. If bran cannot be procured, shorts or flour may be used and for field work may be distributed dry by means of a seed drill.

CRIDDLE MIXTURE.

For Grasshoppers (Locusts).

Take a three-gallon patent pail and fill it with fresh horse droppings, then empty into a barrel ; repeat this five times. As each pailful is poured in, mix thoroughly with the manure about a quarter of a pound of Paris green and half a pound of salt, which has been dissolved in water. There would thus be used about one pound of Paris green and two pounds of salt to half a barrel of manure.

FUNGICIDES.

The principal fungicides in use owe their power to some salt of copper. Such are Bordeaux mixture and its modifications, and ammoniacal copper carbonate, the latter being used chiefly when staining of fruit or foliage such as follows the application of Bordeaux would be objectionable. Potassium sulphide (Liver of Sulphur) is chiefly employed against powdery mildews. These fungi, being of superficial habit, may be successfully combated by less powerful fungicides than the copper salt ones, and of these potassium sulphide has the advantage of being easily prepared and of not staining the plants.

The instructions which follow on the preparation of Bordeaux mixture, soda Bordeaux, copper carbonate, and ammoniacal copper carbonate are taken from Bulletin 154 of the Ontario Department of Agriculture, "Insecticides and Fungicides," by Prof. Harcourt and H. L. Fulmer. This publication is recommended to all interested in spraying. It may be had on application to the Department of Agriculture, Toronto.

BORDEAUX MIXTURE.

The first thing to do in the manufacture of the Bordeaux mixture is to decide on some recommended formula. The formula which has long been advocated in Ontario is known as 4-4-40 formula. It is as follows :—

Crystallized copper sulphate (Bluestone) ...	4 pounds.
Quick lime	4 pounds.
Water	40 gallons.

With good lime it only needs about one pound to act on all the copper; the excess given, three pounds, covers all danger which might arise from the use of a poor article. A large excess of lime is a disadvantage; it causes the Bordeaux mixture to exert a low fungicidal action, it is apt to cause the machinery to clog and to cause an uneven application, and the particles of lime offering more resistance to rain, will cause the mixture to be more rapidly washed from the trees. It may be an advantage, however, in a very wet season, by causing the Bordeaux to retain its efficiency longer and by allowing less injury to be done to foliage.

As both copper sulphate and lime dissolve and slake, respectively, much quicker in hot water than cold, it is better to use heated water in order to save time. The very best lime obtainable is used, and if freshly burned, all the better. In slaking do not use an excess of water, but just enough to keep the lime moist. When the action is completed enough water is added to make a thin whitewash and then the whole is

strained through coarse sacking to remove any lumps which would clog the nozzle of the spray pump. This done, enough water is added to make the volume up to one-half of what the final mixture will amount to. The copper sulphate solution is diluted to the same extent. The two are now mixed, the operation being best performed by two men, each with a bucket, one handling the lime and the other the copper sulphate. They are poured into the spray tank, two bucketsful at a time, until the whole is brought together. In this way a precipitate is obtained which will remain in suspension with only occasional agitation. If mixing is done before dilution, a very coarse precipitate is formed which settles rapidly to the bottom of the spray tank and requires almost constant stirring.

If large quantities of spray mixture are going to be used, it is an excellent plan to make up "stock" solutions of the copper and lime. This can be done by dissolving, say, one pound of copper sulphate in each gallon of water and making up a barrel full of it. Each gallon of the solution taken then represents one pound of the bluestone. The salt can be conveniently dissolved by filling the barrel with water and then suspending it therein, enclosed in a canvas sack. The lime can be handled in the same way, being sure, of course, that the contents of the barrel are thoroughly stirred up before dipping out any portion. Keep the barrels covered when not in use.

PRECAUTIONS TO BE USED IN MAKING. Before Bordeaux mixture is sprayed, it is absolutely necessary that all copper should be in the form of the sky-blue precipitate, *i.e.*, enough lime must be used to act on all the bluestone. Formulæ advocated by the experiment stations always contain enough lime to precipitate all the copper, but it may sometimes happen that such a very poor quality is used that there will be some of the sulphate left unchanged. There are several simple ways by which one can tell when enough lime is present. Those who are very familiar with the reaction which occurs can tell by the color of the precipitate, it having a greenish tinge when an insufficiency of lime is present instead of the deep sky-blue color. However, those who are not familiar with the process must use more decided tests. Three simple ones can be employed, as follows:

1. Take some of the clear solution which is left on top when the sediment settles and place in a white saucer. Add a few drops of a solution of potassium ferrocyanide to it. If a reddish-brown precipitate or coloration appears, more lime is needed.

2. Take a portion of the clear fluid as before, and blow the breath gently over the surface. If a thin white pellicle or covering forms over the top, enough lime has been added.

3. Take a bright piece of steel, such as a knife blade, and hold it in the mixture for a minute or more. If it becomes coated with copper, more lime is required.

iest number one is the most reliable and is the one recommended.

In handling copper solutions use only wooden, brass, and copper vessels; all other receptacles would be corroded and destroyed by them; besides, the fungicide itself would be injured.

Copper compounds are *poisonous* and therefore should not be left lying around where children or animals can get at them.

COMBINED WITH AN INSECTICIDE. Bordeaux mixture is quite often combined with Paris green to impart to it an insecticidal value. In this case the mixture takes the place of water for holding the green in suspension. Other recommended arsenicals can be used for this also, such as lead arsenate and calcium arsenate. But if soluble compounds of arsenic are used, such as sodium arsenite, it would be necessary to slightly increase the amount of lime used in making the original Bordeaux mixture.

SODA BORDEAUX.

This fungicide is made from copper sulphate just as the ordinary Bordeaux mixture. It differs, however, in that caustic soda is used to neutralize the acid property of the bluestone instead of lime; and that the final mixture contains sodium sulphate instead of calcium sulphate (gypsum). The resulting form of the copper, copper hydrate, is exactly the same, and exerts the same fungicidal power.

The main point in connection with this mixture is that caustic soda is an extremely active alkali, and any amount of it added over and above that required to combine with all the copper will destroy foliage. Therefore, in making Soda Bordeaux, *it is important to add just the exact quantity of the soda required to change all the bluestone to copper hydrate*. This is done by adding the soda solution slowly to the copper solution, mixing thoroughly after each addition, and testing for the neutral point with litmus paper. The moment the litmus paper takes on a faintly blue tinge is the time to stop adding. The copper is then all in the form of a sediment and any more alkali added will be left in the free state.

The following tentative formula can be given :

Soda	2 pounds.
Copper sulphate	6 pounds.
Lime	5 ounces.
Water	40 gallons.

In making, add three-quarters of the soda solution at once, mix thoroughly and then add the rest gradually, mixing and testing until the proper quantity is present. It may not require the whole amount recommended, and it may require more, depending upon the quality of the soda. When the alkaline value of a sample of soda is once ascertained, then one can proceed with much more rapidity. The small

amount of lime is added to make the mixture decidedly alkaline, and therefore, safe, and to cause the precipitate to remain blue instead of changing to dark brown or black, which it does after standing some time where an excess of soda is used.

Caustic soda can be bought retail or in drums of one hundred pounds, from or through any chemist, while Gillette's lye, which is familiar to everyone, is a convenient form of soda for use in making Soda Bordeaux.

Soda Bordeaux has an advantage over the ordinary Bordeaux in that it is just as good a fungicide, and at the same time is made without the labor of slaking and preparing of lime. There are disadvantages, however :

1. Great care is necessary in the addition of the caustic soda. Any added in excess is dangerous to foliage; an excess of lime is not harmful, though not advisable.

2. Unless exactly neutral, the addition of an arsenical to Soda Bordeaux to impart to it an insecticidal power, is dangerous. Any free alkali will act upon the arsenic compound and form sodium arsenite, which, being soluble, will scorch foliage.

COPPER CARBONATE.

This valuable fungicide can be readily and easily made at home at much less cost than for what it can be bought on the market. The following method of making is recommended: A barrel is partly filled with water and 25 pounds of copper sulphate are dissolved in it, and into this is poured a solution of 30 pounds of sodium carbonate (common washing soda), when the copper is thrown down as a pale green precipitate of "basic" copper carbonate. This precipitate rapidly settles to the bottom, and after a time the clear solution above can be siphoned off. The barrel is filled with water again, the precipitate stirred up and allowed to settle, and the clear solution again drawn off. This washing removes the greater part of the impurities (sodium sulphate), and leaves behind 12 pounds of basic copper carbonate. This can be removed from the barrel and dried in the air, after which it is ready for use.

AMMONIACAL COPPER CARBONATE.

This spray is made from basic copper carbonate, the preparation of which has just been outlined under "copper carbonate." When ammonia is added to this material, it dissolves to form a deep blue solution, and this solution diluted with the requisite quantity of water forms the well-known spraying compound.

Following are the quantities of material to use :

Copper carbonate	5 ounces.
Ammonia (sp. gr. 26° Beaume)	3 pints.
Water	45 gallons.

RESIN-BORDEAUX.

The surface of some plants, *e.g.*, onion, asparagus, etc., is of such a nature that liquids do not readily wet it, and instead of forming a smooth coating they collect into large drops and fall away. This makes effective spraying difficult. The difficulty may be overcome by using the following preparation (Cornell Bulletin 252):

Resin	2 pounds.
Sal soda crystals	1 pound.
Water	1 gallon.

Boil in an iron vessel (preferably out-of-doors) until the mixture is of a clear, brown color. This will take from one to one and a half hours. Add the above quantity to each 50 gallons of Bordeaux. In wet weather the use of half this quantity in spraying ordinary plants will prevent the washing off of the spray liquid by rain.

POTASSIUM SULPHIDE.

This is also known as "liver of sulphur." As previously mentioned it is used chiefly against powdery mildews, a solution of $\frac{1}{3}$ to $\frac{1}{2}$ an ounce per gallon of water being employed. This should be made in a wooden vessel and used very soon after making, as it decomposes on standing.

In some cases sulphur in fine powder (flowers of sulphur) has been found an effective substitute for potassium sulphide. The powder is simply dusted over the plants and is best applied when the latter are wet.

FORMALIN.

The substance known under this name is a 40% solution of formaldehyde in water. A dilute solution is fatal to fungus spores and such a solution is used as described on page 51 for treating potato tubers. Similar solutions are used for treating seeds.

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Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

DAIRY SCHOOL BULLETIN.

INTRODUCTION.

BY H. H. DEAN, B.S.A., PROFESSOR OF DAIRY HUSBANDRY.

This bulletin has been prepared by the Dairy School Staff in connection with the Ontario Agricultural College. Two new branches have been added, viz., Soft Cheesemaking, and Boilers, Engines, and Piping.

There is a growing demand for soft cheese in Canada, and we have added this as a branch of our Dairy Department of the College. Mr. F. G. Rice, who has charge of this work, is a graduate of the Midland Agricultural and Dairy College, Kingston, Derby, England. Mr. Geo. Travis, who has been one of the Dairy Instructors employed in Western Ontario during the summer for several years, has given the practical instructions regarding boilers, engines, piping, soldering, etc., to the Dairy Classes for the last two years.

Messrs. M. Robertson and Fred Dean are the summer Creamery Instructors, who are now connected with the Dairy School in winter. Mr. G. R. Taylor has charge of the Milk and Cream Testing, Mr. A. McKay is Chief Instructor in Cheesemaking, and Mr. C. H. Ralph is Assistant Cheese Instructor.

DAIRY FARMER. Many dairy farmers grow discouraged during a season of low prices and sell their cows. This is a great mistake. No branch of agriculture is so stable and so remunerative as dairying during a series of years. A year of low prices is usually followed by one of high prices. The cow is undoubtedly the best paying animal on the farm if she is fed and handled properly. However, in order to make a cow pay it is necessary that her owner shall possess certain qualifications. The most important of all is that he shall have a real liking for the cows, not only because of the money which they earn, but he must like them simply because they are cows. A person who really likes cows will take pleasure in feeding and looking after them. To him it is not drudgery. This person will always treat cows kindly and considerately. There will always be a bond of sympathy between the owner and the cow. Each will strive to do the best possible for the other.

The owner of cows must study their habits, likes, and dislikes. He must feed them liberally and make them as comfortable as possible.

Unless he or she is prepared to be a student of cows, success is not probable. To the dairy farmer we should say, know your cows *individually*. This can be best done by weighing the milk from each cow daily, once a week, on two consecutive days each month, or even once a month. Samples for testing should also be taken on the day or days for weighing in order to know the percentage of fat in the milk. This, together with a close observation of the feed consumed by a cow, will enable a dairy farmer to determine whether or not his cows are making a profit. It will also enable him to intelligently weed the poorer cows.

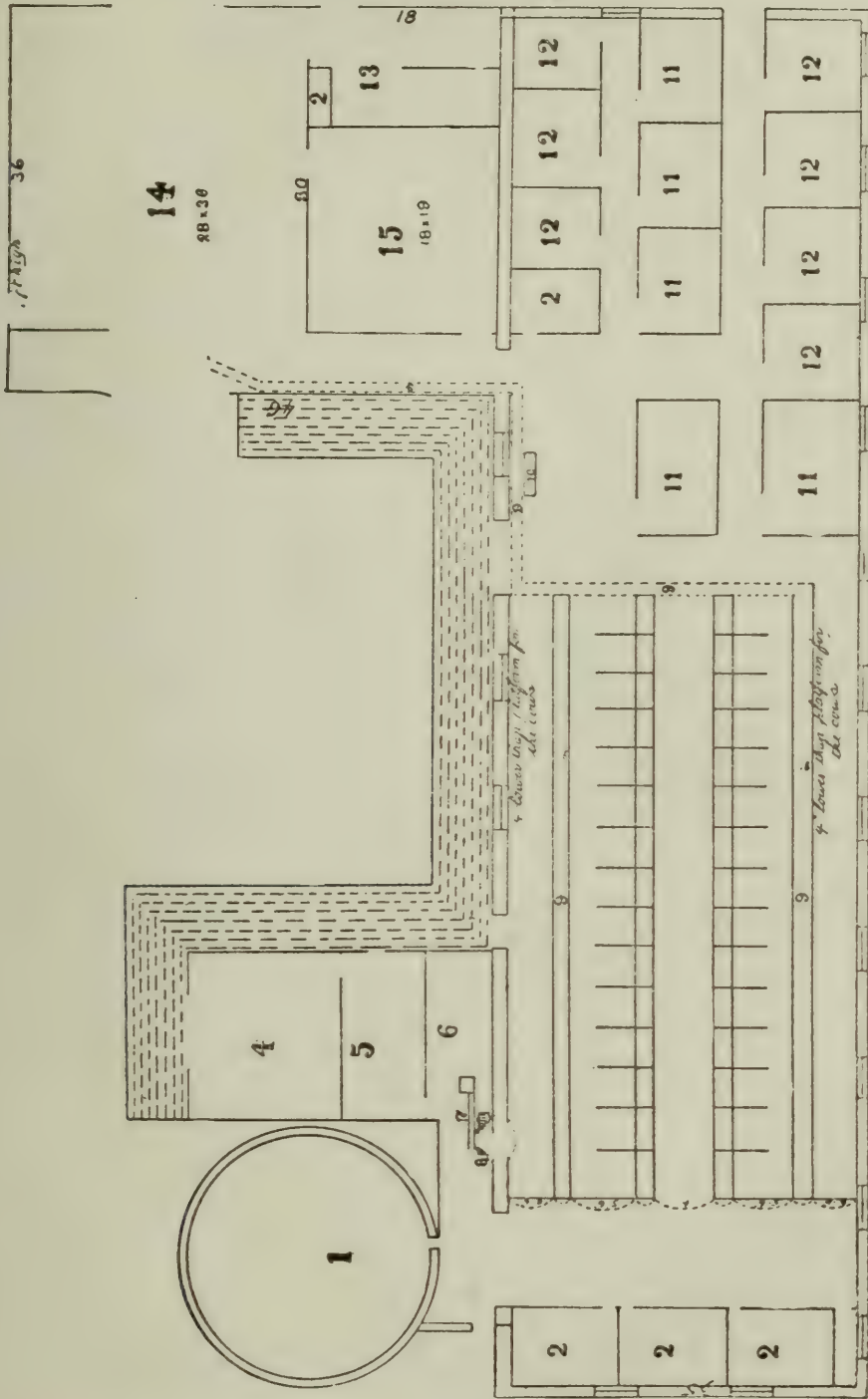
DAIRY COWS may be purchased or they may be bred. Frequently good cows may be bought at reasonable prices, but generally speaking they must be reared by the dairy farmer. For the dairyman who cannot afford to keep pure-bred cows, it is desirable to select grade or native cows and breed these to a pure-bred male belonging to one of the dairy breeds. Great attention should be paid to the sire, as milking quality in the female depends more on the sire than on the dam. Dairy farmers do not sufficiently realize the importance of this point. Excellent dairy cows may be secured at small cost by using a dairy sire belonging to a dairy breed and a dairy family. In this way a herd of ordinary or inferior breeding may soon be transformed into a herd of good milkers. The fundamental mistake made by many breeders of dairy cows is in the use of inferior or what are commonly called "scrub" sires. The patrons of every cheese factory and creamery ought to have the use of a pure-bred bull at nominal cost. It would pay the factories to adopt some co-operative plan to secure this result.

Calves and heifers for the dairy should be kept in a thrifty condition but not too fat. They should commence milking when about two and one-half years old. At the end of the second lactation period and during all future years they should produce not less than 6,000 lbs. milk or 250 lbs. butter yearly. This may be taken as a minimum standard of production for profitable dairy cows. Stated another way, they should earn from \$25 to \$100 per cow each year, above the cost of feed.

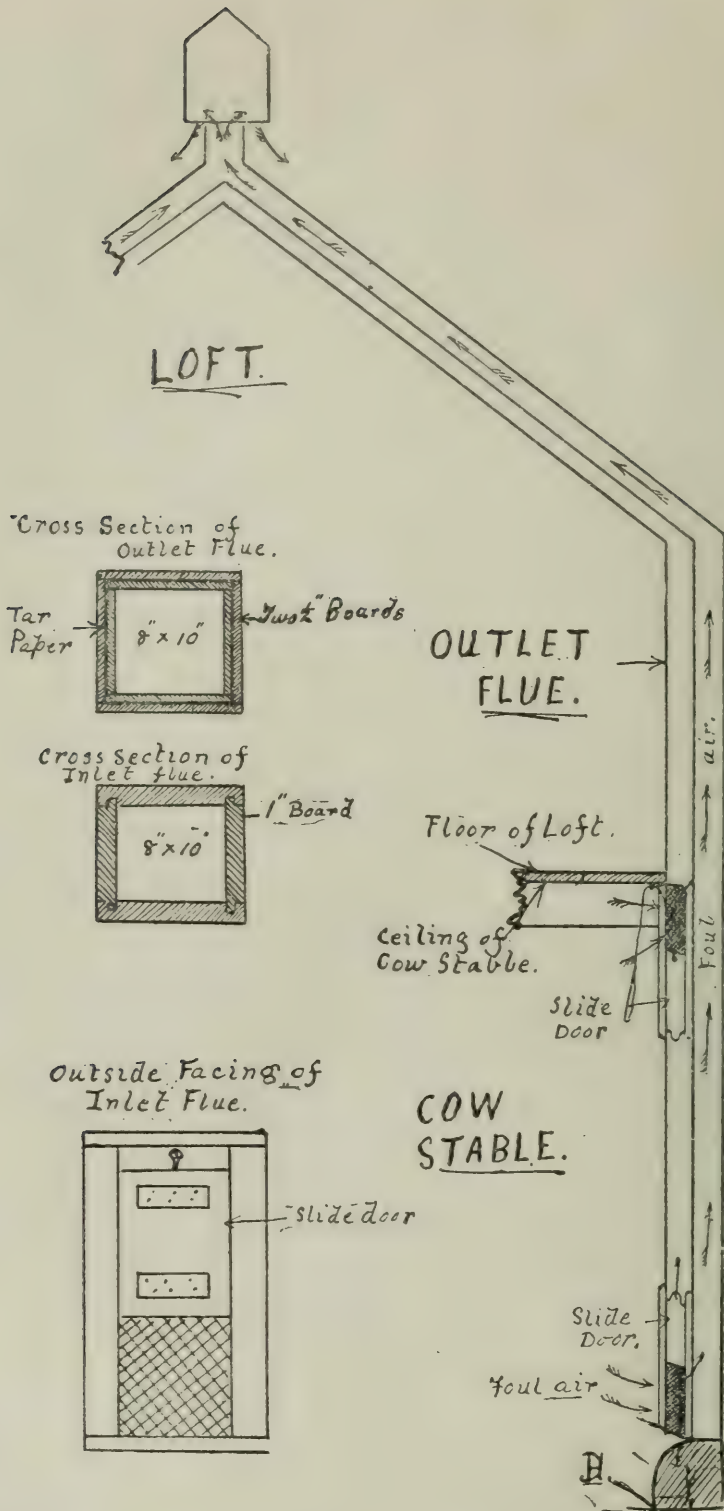
DAIRY STABLE. The chief requirements in a dairy stable are that it shall be light, clean, and healthful. The first is got by having plenty of clean windows, the second by having cement floors, with stalls of proper length and a gutter or drop behind the cows, and the last by having the stable well ventilated, and whitewashed at least once a year. Mangers are not necessary in a modern cow stable.

Conditions vary so much on different farms that it is difficult to give a plan suitable for all farms. The accompanying illustrations will show the arrangements in the dairy stable of the College, and on the whole it is quite satisfactory. The feed bins are located at one end of the stable and the box stalls, eleven in number, at the other. There is room for thirty cows to be tied up. A large room above the stable holds the hay and straw. This is not the most sanitary arrangement, but it is convenient.

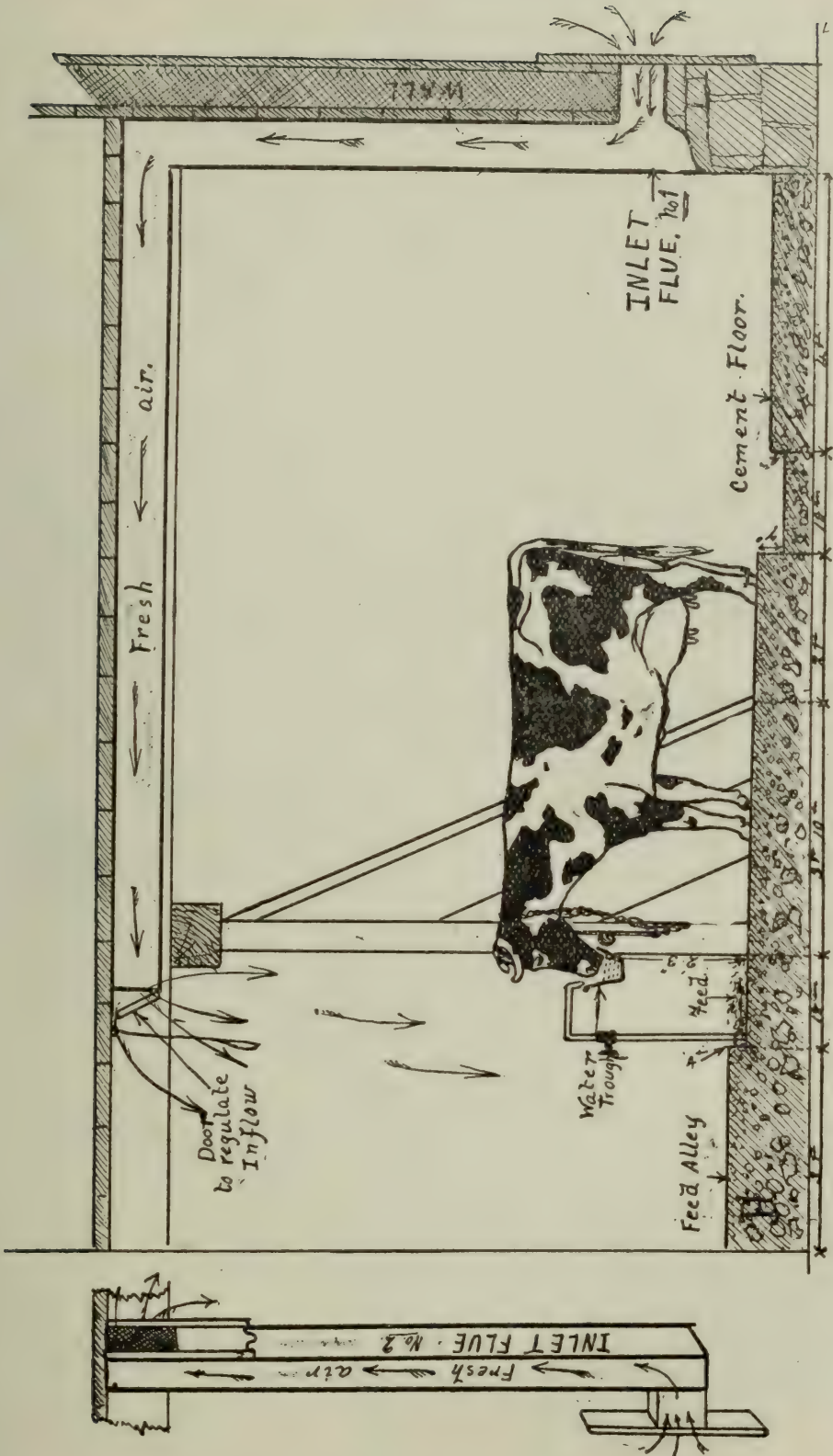
The King system of ventilating is the one adopted in the dairy stable and it is quite satisfactory. There are six inlets and eight outlets. The



cost of putting in the ventilation was \$136, including the cost of galvanized iron ventilators, of which there are four connected with the eight outlets from the stable.



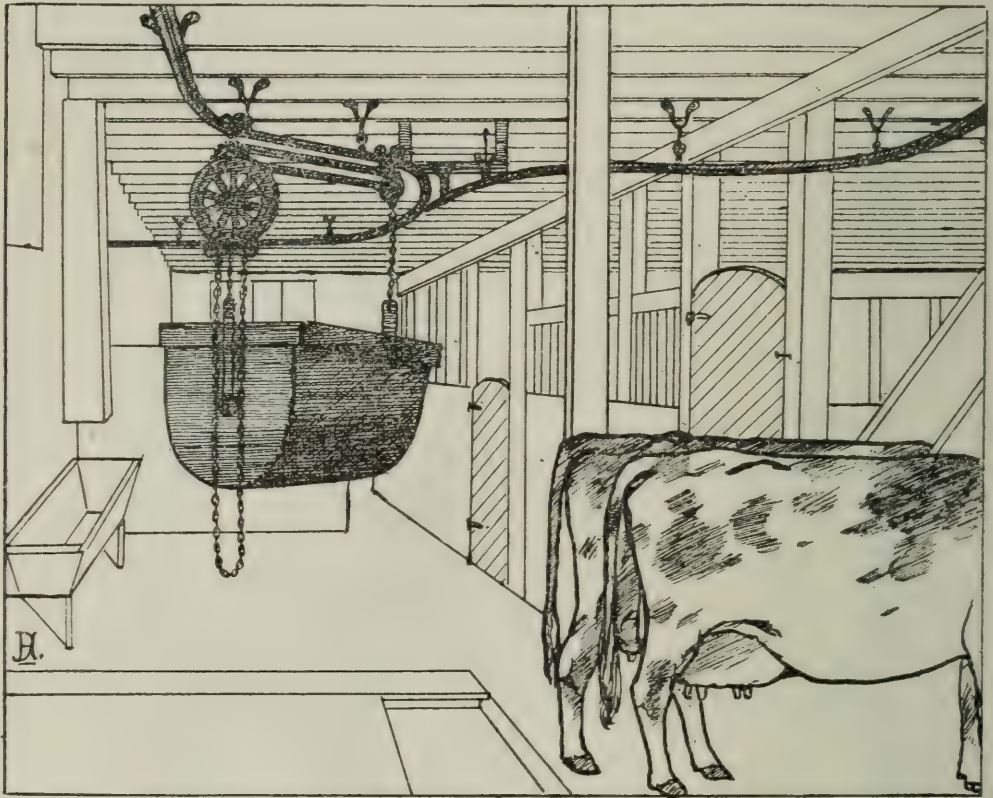
Plan showing outlet for foul air. There are eight of these in the stable—four on each side. One from each side enters a ventilator at roof.



Cross section of stable showing one-half the feeding alley, place for feeding, water trough, stall, gutter, passage behind the cows and inlets of fresh air. There are six of these inlets, one-half of which open at the ceiling behind the cows and one-half in the centre of the stable.

FEEDING THE COW. The natural food of the cow is grass, and nothing is equal to good pasture for cows. In order to secure good pasture on cultivated land it is advisable to give more attention to the method of, and mixture used for, seeding. A very good combination of grasses and clovers, where a rotation of crops is practised, is the following: 4 lbs. timothy, 5 lbs. orchard grass, 7 lbs. red clover, and 2 lbs. alsike clover, making 18 lbs. of seed per acre.

On fields which may be allowed to remain in pasture for several years, the following mixture is recommended by Prof. Zavitz: 4 lbs. orchard grass, 4 lbs. meadow fescue, 3 lbs. tall oat-grass, 2 lbs. timothy, 2 lbs. meadow foxtail, 5 lbs. lucerne clover, 2 lbs. alsike, and 2 lbs. white clover, making 24 lbs. of seed per acre.



Litter carrier, a great convenience for cleaning Dairy Stable.

The same authority recommends for a pasture crop to be used the same year as sown, 51 lbs. oats, 30 lbs. early amber sugar cane, and 7 lbs. red clover—a total of 88 lbs. per acre. Cows are very fond of this mixture.

Lucerne or Alfalfa is another crop which dairy farmers should grow. It may be used for green fodder, hay, pasture, and for green manure. For hay it should be cut when less than one-third in bloom. It is claimed that a ton of lucerne hay is equal to a ton of bran for milk production. This crop should receive more attention on dairy farms. About 18 lbs.

of seed per acre should be sown on well-drained land in the spring, with or without a crop. It should not be pastured or cut the *first* year. It will give two or three cuttings each year after it is established.

To supplement pastures, green peas and oats, or summer silage are often necessary. These help to maintain the milk flow at a time when the shrinkage would otherwise be considerable. From two to four pounds of meal per cow each day will often pay when the prices of dairy produce are good. This meal may consist of bran and oats, or either of them alone.

For winter feeding, corn silage is undoubtedly the cheapest bulky food at the disposal of dairymen. However, corn silage alone is not sufficient for milking cows. They also need some clover hay, roots, and meal. When dry, it pays to feed the cows a moderate amount of meal, as it seems to be a recognized principle that the time to renew a cow is when she is not milking. Too many put their cows on short rations when they are not milking, thus violating the foregoing principle, and the results are not satisfactory. It pays to feed a good cow well when dry. With heavy milkers there is danger of losing the cows through "milk fever," but modern methods of treating this disease make it comparatively harmless, and there is very much less risk now than formerly. Under ordinary conditions the best plan with heavy milkers in high flesh is to not milk the cow any more than is required for the calf for the first two or three days. If the cow is attacked, the "air treatment" is simple and effective.

On the one hand many cow feeders fail to give their animals sufficient to maintain a proper milk flow, while on the other, some feeders give more meal than the cows can profitably assimilate. Experiments indicate that cows in full flow of milk should receive about eight pounds of meal daily, together with all the roughage which they can consume. An increase to twelve pounds of meal daily in most cases means an added cost for the milk and butter out of proportion to the increased yield.

The winter feed at the dairy barn of the College is prepared as follows: The hay is cut and mixed with the corn silage and pulped mangels for several hours before feeding. This roughage is given at two feeds, and on it is placed the meal for each cow at the time of feeding. The meal usually consists of bran, oats and oilmeal. A feed of long hay is given once a day in addition to the regular feed.

Our standard ration consists of about

40 lbs. corn silage,
10 lbs. clover hay,
30 lbs. mangels,

4 lbs. wheat bran,
3 lbs. ground oats,
1 lb. oil meal.

The following table is based on Bulletin 154 from Cornell Station :

DIGESTIVE NUTRIENTS IN ONE POUND OF SOME COMMON FEEDING STUFFS.

Kind of Food.	Total dry matter.	Pounds of digestible nutrients.			Nutritive Ratio
		Protein.	Carbo-hydrates. + (fat x 2.25).	Total.	
Green fodder corn, 1 lb.....	0.20	0.010	0.125	0.135	1:12.5
“ peas and oats, “	0.16	0.018	0.076	0.094	1:4.2
“ red clover, “	0.29	0.029	0.164	0.193	1:5.6
“ alfalfa clover, “	0.28	0.039	0.138	0.177	1:3.5
Corn silage, “	0.21	0.009	0.129	0.138	1:14.3
Potatoes, “	0.21	0.009	0.165	0.174	1:18.3
Mangels, “	0.09	0.011	0.056	0.067	1:5.1
Sugar Beets, “	0.13	0.011	0.104	0.115	1:9.4
Carrots, “	0.11	0.008	0.082	0.090	1:10.3
Turnips, “	0.10	0.010	0.077	0.087	1:7.7
Timothy hay, “	0.87	0.028	0.465	0.493	1:16.6
Mixed hay, “	0.87	0.062	0.460	0.522	1:7.4
Red clover hay, “	0.85	0.068	0.396	0.464	1:5.8
Alfalfa hay, “	0.92	0.110	0.423	0.533	1:3.8
Corn fodder, “	0.58	0.025	0.373	0.398	1:14.9
Corn stover, “	0.60	0.017	0.340	0.357	1:19.9
Pea straw, “	0.86	0.043	0.341	0.384	1:7.9
Wheat straw, “	0.90	0.004	0.372	0.376	1:93
Oat straw “	0.91	0.012	0.404	0.416	1:33.6
Corn, (grain) “	0.89	0.079	0.764	0.843	1:9.7
Wheat, “	0.90	0.102	0.730	0.832	1:7.2
Rye, “	0.88	0.099	0.700	0.499	1:7.1
Barley, “	0.89	0.087	0.692	0.779	1:7.9
Oats, “	0.89	0.092	0.568	0.660	1:6.2
Buckwheat, “	0.87	0.077	0.533	0.610	1:6.9
Peas, “	0.90	0.168	0.534	0.702	1:3.2
Corn and cob meal, “	0.85	0.044	0.665	0.709	1:15.1
Wheat bran, “	0.88	0.122	0.453	0.575	1:3.7
Wheat middlings, “	0.88	0.128	0.607	0.735	1:4.7
Low grade flour, “	0.88	0.082	0.647	0.729	1:7.9
Gluten feed, “	0.92	0.194	0.633	0.827	1:3.3
Gluten meal, “	0.92	0.258	0.656	0.914	1:2.5
Linseed meal (new process) 1 lb.	0.90	0.282	0.464	0.746	1:1.6
Cotton seed meal, “	0.92	0.372	0.444	0.816	1:1.2
Sugar beet pulp, “	0.10	0.006	0.073	0.079	1:12
Apple pomace, “	0.233	0.011	0.164	0.175	1:14.9
Skim-milk (separator), “	0.094	0.029	0.059	0.088	1:2
Buttermilk, “	0.10	0.039	0.065	0.104	1:1.7

To find the pounds of nutrients in any given number of pounds of any feeding-stuff multiply the weight of nutrients in one pound as given in the table, by the pounds fodder, meal, etc., which you expect to feed.

By referring to the preceding table we find that our ration contains digestible material as follows :

Feeding Stuffs.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbo-hydrates. + (fat x 2.25.)	Total.	
Corn silage, 40 lbs.....	8.40	0.360	5.160	5.520	.....
Clover hay, 10 ".....	8.50	0.680	3.960	4.640	.....
Mangels, 30 ".....	2.70	0.330	1.680	2.010	.....
Bran, 4 ".....	3.52	0.488	1.812	2.300	.....
Oats, 3 ".....	2.67	0.276	1.704	1.980	.....
Oil Cake, 1 lb.....	0.90	0.282	0.464	0.746	.....
	26.69	2.416	14.780	17.196	1:6.1
Wisconsin standard	24.5	2.20	14.900	17.100	1:6.8
German ".....	24.0	2.50	13.400	15.900	1:5.4

By comparing it with the Wisconsin and German standards, we find that it contains more dry matter than is called for by either, more protein than is asked for in the Wisconsin and less than the German, more carbonaceous material than the German and slightly less than in the Wisconsin, the total digestible material is greater than in the German and about the same as the Wisconsin, while its nutritive ratio is between the two standards, but conforming more nearly to that of Wisconsin.

By using the table as directed any farmer can readily find out the amount of digestible material in his ration and compare it with the standards given. If he finds that the ration is too low in protein or muscle-forming material, then bran, oil-meal, gluten meal, peas or clover hay should be added to the ration, and if necessary some of the more carbonaceous foods such as silage, may be reduced. However, silage, roots, beet pulp, etc., give succulency to the ration which is very important in the economical production of winter milk.

FACTORY FLOORS. Substitute, as soon as possible, a cement floor for the wooden floor now in the factory. Grade the ground to a slant of one inch in six feet to a central gutter, then pack the earth firmly and cover with four to six inches of gravel. Pound the gravel solidly. Mix sand and gravel with good cement in the proportion of four or five to one, and lay the grouting about four inches thick on the firm gravel. Finish with one inch of screened sharp sand and the very best brand of cement mixed in the proportion of two to one for the finishing coat. Have the surface smooth so that pools of water will not lie on the floor. The gutter should

have a fall of one inch in six to eight feet, to an outlet, and should be made specially solid and even on the side and bottom. Employ a skilled workman to lay the floor, and use none but the very best material.

Place a "bell-trap" at the outlet from the gutter. Use sewer tile with cemented joints in underground drains near the factory, to prevent sewage soaking into the well. The sewage may be disposed of by means of a filter-bed or by the sub-earth system. Do not allow it to accumulate about the factory.

PAYING PATRONS. Milk is valuable for buttermaking in proportion to the fat which it contains, and the pounds of fat delivered in the milk or cream should form the basis of dividing proceeds among patrons of the creameries.

As butter consists of fat, together with about 16 per cent. of water, salt, and curdy matter, there will always be more butter than the fat contained in the milk or cream. This excess of butter over fat constitutes what is known as the "overrun." The "overrun" in whole milk creameries varies from 12 to 16 per cent., *i.e.*, 100 lbs. fat in the milk makes from 112 to 116 pounds of butter, and this "overrun" belongs to the patrons, unless otherwise understood. It is unwise for creamery managers to take the "overrun" as part payment for manufacturing.

In cream-gathering creameries the overrun usually varies from 12 to 20 per cent.

For calculating the yield of butter from fat in the milk, adding one-sixth to the fat is near enough for practical purposes.

Cheese is made largely from two constituents in the milk, *viz.*, fat and casein; therefore, the method of dividing proceeds among the patrons of cheese factories is more complicated than for creameries. Three systems are now in use among factorymen:

1. Paying according to the weight of milk delivered regardless of its quality.

The principle of this plan is that it assumes all milk to be of equal value per 100 pounds for cheesemaking. It rests on a false assumption, is unjust, and it tends to promote dishonesty. Factorymen and honest patrons who complain that some of the milk is skimmed and watered by dishonest patrons, deserve little sympathy, because a remedy is within the reach of all at a very small cost. The milk of all patrons should be tested regularly, and be paid for according to its value for cheesemaking.

2. Paying according to the weight of the fat delivered in the milk, the same as at creameries.

The principle of this system is that it assumes all milk to be valuable for cheesemaking in proportion to the fat which it contains. The system

is manifestly more just and equitable than the first named, and is to be commended in preference to "pooling" by weight of milk. The chief weakness of the plan is that the yield of cheese is not in direct proportion to the fat contained in the milk; therefore, it gives an undue advantage to the patrons sending milk containing a high percentage of fat.

3. Paying according to the fat and casein in the milk, the casein being represented by the factor 2, added to the percentage of fat.

The principle of this system is that it assumes milk to be valuable for cheesemaking in proportion to the fat and casein contained in it, and it further assumes that the percentage of fat + 2 represents the available fat and curdy compounds in milk for cheesemaking.

The application of the third system is very simple. To illustrate: the tests for fat of patrons' milk are 3.0, 3.5, 3.8 and 4.0. The percentage of fat and casein are $3 + 2 = 5.0$; $3.5 + 2 = 5.5$; $3.8 + 2 = 5.8$; and $4 + 2 = 6.0$. The pounds of fat and casein are calculated by multiplying the pounds of milk delivered by the percentage of fat and casein. Thus, if the first patron had 1,500 lbs. milk he would be credited with $1,500 \times 5 \div 100 = 75$ pounds of fat and casein. If the second delivered 2,000 pounds milk he would be credited with $2,000 \times 5.5 \div 100$, or 110 pounds of fat and casein, and so on with all the others. The value of one pound of fat and casein is ascertained by dividing the net proceeds of the sale of cheese by the total pounds of fat and casein delivered.

The following table gives a summary of the results obtained during five years' experiments, in which 250 experiments were made with nearly 200,000 pounds of milk, which contained percentages of fat varying from 2.7 to 5.5.

Av. p.c. fat in milk.	Lbs. cheese made per 100 lbs. milk.	Lbs. cheese made per 1 lb. fat in milk.	Lbs. cheese made per lb. fat and casein or p.c. fat + 2.	Lbs. loss of fat and casein in whey.		Per cent. lost in curing in four weeks.	Average score.	
				Per 1,000 lbs. milk.	Per 100 lbs. cured cheese.		Flavor max. 35.	Total max. 100.
2.87	8.75	3.04	1.79	2.71	3.09	4.26	30.4	89.9
3.22	9.03	2.80	1.72	2.75	3.15	4.43	30.2	89.4
3.83	10.02	2.61	1.71	3.34	3.21	4.10	30.8	90.3
4.23	10.67	2.53	1.71	3.21	3.02	4.05	31.0	90.4
4.74	11.44	2.41	1.69	3.64*	3.18*	3.07	31.0	89.8
5.21	12.13	2.32	1.68	3.40*	2.80*	3.53	31.5	91.6

* Fat only. Casein not determined.

Amounts of money (cheese 8c per pound) credited by three systems and also value of cheese.

Average p.c. fat in milk.	Weight of milk— 1,000 lbs. milk.	Weight fat in 1,000 lbs. milk.	Weight of fat and casein in 1,000 lbs. milk, or fat plus 2.	Value cheese made from 1,000 lbs. milk.
	\$ c.	\$ c.	\$ c.	\$ c.
2.87	8 27	5 91	6 69	7 00
3.22	8 27	6 63	7 18	7 22
3.83	8 27	7 89	8 02	8 02
4.23	8 27	8 71	8 56	8 54
4.74	8 27	9 76	9 27	9 15
5.21	8 27	10 73	9 91	9 70

“Our five years’ experiments prove that this third system comes nearest to the actual value of the cheese produced, though it still places a slight premium on the milk-fat. It encourages the production of good milk, and at the same time does not discourage the majority of patrons who have average milk, and who are apt to envy those whose cows give a small amount of rich milk, and who draw a large share of the proceeds of cheese-sales, when the money is divided on the basis of the fat only.”
—O.A.C. Report, 1898, p. 52.

The Hart Casein Test has proven satisfactory, and enables us to obtain the percentage of casein in milk, but it does not change the principle of this third method.

SKIM-MILK AND WHEY. The value of skim-milk for young calves and pigs is much increased by feeding it sweet. The whole milk creamery should heat all skim-milk to 185 degrees, before it leaves the creamery. Sweet skim-milk is probably worth 15 to 20 cents per 100 pounds. It has also about the same value for grown pigs when sour, if fed along with meal.

Buttermilk has about the same value as sour skim-milk, if it does not contain too much water. When selling buttermilk in bulk at the creamery a convenient way is to value it at so much per ton of butter. From \$5 to \$8 per ton of butter is a fair price.

Experiments made at the Ontario Agricultural College showed that 100 pounds of whey were equal to 14 pounds of meal in the production of bacon. Both skim-milk and whey had a marked influence in the production of *firm* bacon. When selling whey in bulk at the factory, it is usually valued at from five to ten dollars per ton of cheese.

The by-products of cheesemaking and buttermaking are valuable factors in adding to the wealth of dairymen by means of feeding bacon hogs and young cattle for beef and the dairy.

All these by-products ought to be pasteurized at the factory before returning them to the farm. Whey heated to 160° F. for one hour in the whey tank will likely destroy the germs which produce tuberculosis in hogs and other animals. All cheese factories ought to pasteurize the whey. It improves the feeding quality, lessens danger of spreading disease, and reduces danger from bad flavors in milk and cheese, as most of the organisms causing these flavors are killed by heating. The cost of pasteurizing the whey has been estimated at 50 cents to one dollar per ton of cheese.

THE ALKALINE SOLUTION: ITS PREPARATION AND USE.

BY R. HARCOURT, B.S.A., PROFESSOR OF CHEMISTRY.

CAUSES OF ACIDITY IN MILK. The development of acid is caused by the breaking down of milk sugar into lactic acid, through the influence of certain acid-forming ferments in the milk. But even sweet milk, immediately after it is drawn from the udder, will have an acid reaction with certain indicators. This acidity is not due to lactic acid nor any free acid in the milk, but to the acid nature of the ash constituents, possibly also to the carbonic acid gas it contains, and to the acid nature of the casein. When phenolphthalein is used as an indicator, freshly drawn milk will generally show as much as .10 per cent. of acid and immediately after exposure to the atmosphere, lactic acid germs commence breaking down the milk sugar. At a temperature of 70° to 90° F., these germs multiply at an enormous rate, consequently lactic acid will develop very rapidly in milk during a warm or sultry day or night. Cooling retards the action, but even at a temperature of 40° to 50° F. they will multiply and considerable lactic acid will be formed. Milk intended for cheesemaking should not contain more than .20 per cent. acid when delivered at the factory; whereas it does not usually smell or taste sour until it contains .30 to .35 per cent. A further development of acid will cause the milk to curdle, or, in other words, will produce coagulation of the casein. There is, however, a limit to the development of acid; for, after a certain point, the germs which break down the milk sugar are destroyed by the acid they produce, and there is no further increase in acidity.

In many ways a knowledge of the acid contents of milk or its products is of value. In most cases, a determination of the percentage of acid in the milk when delivered at the factory will indicate the care the milk has received previous to that time. The acid test may be of value in selecting milk best adapted for pasteurization, or for retail trade, or manufacture of high-grade products. At the present time, however, the chief uses made of the alkaline solution in dairy work are to determine the acid in cream intended for churning, and the acid in milk and whey

in the various steps in the process of the manufacture of cheese. Both in ripening cream and in cheesemaking, acid is developed, and the alkaline solution is now frequently used to measure the amount of acid present and thus control the work.

HOW TO MEASURE THE ACIDITY. The measurement of the amount of acid or alkali in a solution depends upon the fact that it always takes a definite quantity of alkali to neutralize a definite quantity of acid. Thus, for instance, it always takes a definite quantity of caustic soda to neutralize a definite quantity of lactic acid, sulphuric acid, or any other acid. If, then, we know the strength of a given caustic soda solution and measure the amount of it used to render a definite amount of milk or cream neither acid nor alkaline, but neutral, we can figure the amount of acid in the sample taken. To make such a determination we require the following:

1st. A standard solution of caustic soda, usually made of the strength known as .111 normal.

2nd. An indicator—some chemical which, added to the milk, indicates by change of color when enough of the alkaline solution has been added to render the milk neutral. Phenolphthalein is the one most commonly used for this purpose. It is made by dissolving 10 grams of phenolphthalein in 300 c.c. of 80 per cent. alcohol.

3rd. A burette, graduated to 1-10 of a cubic centimeter, in which to measure the amount of solution used.

4th. A pipette, to measure the milk or cream.

5th. A glass or porcelain cup, and a stirring rod. A complete outfit suitable for use in butter and cheese factories may now be procured from almost any of the dairy supply firms.

For the information of those who want to make their own alkaline solution or who may wish to check the strength of a solution on hand, the following directions are given:

PREPARATION OF SOLUTIONS. The caustic soda solution may be prepared by a druggist or one who has a delicate balance at hand by carefully weighing out 4.4 grams of pure sodium hydroxide and dissolving in one litre (1,000 c.c.) of water. But impurities in the sodium hydroxide and lack of delicate enough balance make this method unreliable.

The most accurate way of preparing this solution is by standardizing it against an acid diluted to the same strength as the alkaline solution wanted. As it requires an experienced chemist to prepare this acid of the strength required, it is important that it be got from a reliable source.

Having on hand, then, a .111 normal solution of acid, the object is to make a solution of the alkali, 1 c.c. of which will exactly neutralize 1 c.c. of the acid. For this purpose, dissolve 5 grams sodium hydroxide (NaOH) in one litre of water. If the soda contains much carbonate, it must be removed by adding a little of a solution of barium hydroxide, boiling, and filtering off the precipitated carbonates. The relative strength of the acid and alkali solution is next determined. This is done as follows:

Rinse out a clean burette two or three times with the acid solution, and then fill it with the same. Note the exact point at which the surface of the liquid stands in the burette; measure out 10 c.c. of the alkaline solution, and deliver into a clean beaker, glass or porcelain cup. Dilute with about 50 c.c. of water, add three or four drops of the phenolphthalein indicator, and then stirring all the time, let the acid from the burette drop slowly into the alkaline solution, until the color first produced by the indicator is just destroyed. This is the neutral point. Now, again note the exact point at which the surface of the liquid stands in the burette. The difference between the two readings is the amount of acid required to neutralize the 10 c.c. of alkali. If care be taken in coming to the neutral point slowly, it will be seen that one drop finally destroys the last of the light pink color. This work should be repeated until accuracy is assured. The following is an example of results:

1st. 10 c.c. of alkali required 11.5 c.c. of acid for neutralization.

2nd. 10 c.c. of alkali required 11.45 c.c. of acid for neutralization.

3rd. 10 c.c. of alkali required 11.5 c.c. of acid for neutralization.

In this case, we would accept 10 to 11.5 as the relative strength of the two solutions. The alkali is, therefore, the stronger, and must be diluted. If 1.5 c.c. of water be added to 10 c.c. of the alkali solution, 1 c.c. of the alkali ought exactly to neutralize 1 c.c. of the acid. Therefore, for every 10 c.c. of the alkali solution add 1.5 c.c. of water. Measure out the amount of the solution and pour into a clean dry bottle. Calculate the amount of water required to dilute the alkali to the proper strength, and add it to the contents of the bottle. Mix well, and test correctness of work by proving that 10 c.c. of the one solution will exactly neutralize 10 c.c. of the other. If it does this, the solution is correct.

TESTING THE ACIDITY OF MILK OR CREAM. By means of a pipette (a 10 c.c. is a convenient size) measure out a definite quantity of the milk or cream to be tested and deliver into a beaker or cup. If distilled or rain water is handy rinse out a pipette once, and add the rinsings to the sample. Dilute with 50 c.c. of water, and add three or four drops of the indicator. Now, having the alkaline solution in the burette, carefully note the point at which the surface of the liquid stands in the burette and then cautiously let it drop into the cream or milk being tested. Keep the sample well stirred while adding the alkali. The acid in the sample will gradually be neutralized by the alkali added until at last a uniform pink color appears, which will slowly fade away. The most delicate point is the first change to the uniform pink color, which the sample shows when the acid contained therein has been just neutralized. Because of the influence of carbonic acid of the atmosphere the pink color is not permanent unless a slight excess of alkali solution has been added. The operator should not, therefore, be led to believe by the disappearance of the color after a short time, that the neutral point has not been reached. Having decided on the neutral point, again read the burette

at the surface of the liquid, and the difference between this reading and the first is the amount of alkali solution used to neutralize the acid in the sample taken.

The calculation of the per cent. of acid is simple. The alkaline solution used is of such a strength that when a 10 c.c. pipette is used, the number of cubic centimeters of alkaline solution required to neutralize the acid in the milk or cream has simply to be multiplied by 0.1. Thus, if 5.6 cubic centimeters of the alkali be used then $5.6 \times 0.1 = .56$ per cent. acid.

To insure accuracy the utmost care and cleanliness must be observed in every detail of the work. All water used with the milk or cream or in making the alkaline solution should be either distilled or pure rain water. The burette and pipette, after being washed, must be rinsed out two or three times with the solution they are intended to measure.

The knowledge the operator may gain from such tests will not only make it possible for him to turn out more uniform products, but it will also enable him to act with confidence and more intelligently to pursue the work he may have on hand.

MILK AND CREAM TESTING.

BY GEO. R. TAYLOR.

Milk varies considerably in composition, therefore, it is necessary to test it. The chief constituents are fat, casein, sugar, albumen, mineral matter, ash, and a large percentage of water.

Of these constituents the fat is the most variable, and, by some, is considered to be the most valuable. In fact, the fat is often used as an index to the commercial value of milk. This shows the importance of having a test for fat which is simple, reliable and accurate, also the necessity of knowledge and ability on the part of the operator to successfully conduct the test.

The Babcock test has been in use for several years, and has proved beyond doubt its reliability as a practical test, not only for determining the amount of fat in milk and cream but also for detecting the extent of losses in skim-milk, buttermilk and whey due to faulty methods of manufacturing. The test is also of great value to the milk producer in assisting him to determine the value of individual cows in his herd, and when used in conjunction with the lactometer it assists in detecting some of the common adulterations in milk, such as watering and skimming.

The details connected with a determination of fat by the Babcock test are briefly as follows:—

1. Thoroughly mix the milk by pouring from one vessel to another. When a thick cream has formed on top it will be necessary to warm the sample slightly by placing in warm water before mixing. If the sample is not properly mixed a representative sample cannot be obtained and the test is of no value.

2. By means of a 17.6 c.c. (cubic centimeter) pipette, measure approximately 18 grams of milk at a temperature of from 60 to 70 degrees F., into a milk test bottle.

3. Add to this 17.5 c.c. of commercial Sulphuric Acid having a specific gravity 1.82 to 1.83, then mix the milk and acid thoroughly by giving the bottles a gentle rotary motion. The acid should be at a temperature of 60 to 70 degrees F.

4. Place the bottles in the tester, making sure that the bottles in the machine are properly balanced, and turn for five minutes at full speed, which will vary from 700 to 1,200 revolutions per minute according to the diameter of the test—800 revolutions per minute for an eighteen inch diameter machine.

5. Add hot water at a temperature of not less than 140 degrees F. to float the fat into the neck of the bottle. Water at a temperature of 160 degrees F. will give better results with hand testers when working in a cool room.

6. Turn the tester again for two minutes at full speed.

7. Place the samples in water at a temperature of 140 degrees F. for several minutes before taking the readings.

NOTES.

1. Always make sure that the pipettes and test bottles are clean before using.

2. Be very careful to measure the exact amount of milk for a test. A 17.6 c.c. pipette will deliver about 17.5 c.c. of milk. This measurement of milk of average quality will weight about 18 grams.

3. A partially churned sample of milk may be prepared for sampling by heating it to about 110 degrees F. and pouring it from one vessel to another to mix it thoroughly. When it is thus prepared, take a sample as quickly as possible, and cool to about 60 degrees F. before adding the acid.

4. In sampling frozen milk it is necessary that both the liquid and the frozen part be warmed and mixed thoroughly. The unfrozen part is richer in fat and solids than the frozen.

5. A sample of milk that has soured and thickened may be prepared for sampling by adding a small amount of some alkali to neutralize the lactic acid, and cause the curd to redissolve. A small amount of powdered concentrated lye is very suitable. Add just a small amount of lye at a time, and pour the milk from one vessel to another, to mix the lye with the milk, which causes the casein to become dissolvable.

6. The amount of acid used must be varied to suit its strength. The right amount is being used when the fat presents a bright golden appearance. Acid that is much too strong or too weak should be discarded, as satisfactory results cannot be obtained from its use. Acid a little weak is to be preferred to very strong acid. Carboys or bottles con-

taining acid should be kept well corked, to prevent the contents becoming weakened by absorbing moisture from the atmosphere.

7. Avoid pouring the acid directly on the milk. The test bottle should be held at an angle so as to cause the acid to follow the side of the bottle and go directly underneath the milk. After the addition of the acid to the test bottle the milk and acid should be in two distinct layers without any charred matter between them. A thorough mixing by means of a gentle rotary motion should be given at once.

8. If using hand testers in a room at a low temperature, it may be necessary to keep sufficient hot water in the machines to maintain a temperature of 140 degrees F. in the test bottles.

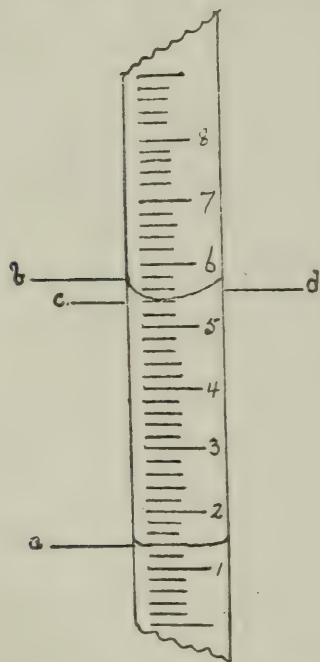
9. The water added to the test bottles should be soft or distilled. If hard water is used, add a little sulphuric acid (half an acid measure, or a little more to a gallon of water) to soften it; this will prevent foam above the fat.

10. If there are several readings to take, *always* set the samples in hot water (140 degrees F.) extending to the *top of the fat* before reading.

11. It is well to use a pair of dividers or compasses for measuring the column of fat. The points of the dividers should be placed at the upper and lower limits of the fat column; then if one point of the dividers be placed at the zero mark of the scale, the division at which the other point touches will show the percentage of fat in the sample tested.

12. The accompanying illustration will show the correct method of reading milk tests when the fat is at a temperature of 140 degrees F.

The reading should be taken from *a* to *b*, not to *c* or *d*.



13. Burnt or cloudy readings may be caused by:—

(1) The use of too much or too strong acid.

(2) Allowing the acid to fall directly on the milk.

(3) Having the milk or acid at too high a temperature.

(4) Allowing a sample to stand too long after adding the acid, before mixing the milk and acid.

14. Light colored readings and floating particles of curd are usually due to:—

(1) The use of too little or too weak acid.

(2) Having the milk or acid at too low a temperature.

(3) Insufficient shaking of the bottles to unite the milk and acid thoroughly.

(4) Lack of required speed or time in whirling.

15. A convenient method of testing the accuracy of the graduation is to test the same milk in the different test bottles. A bottle that differs by more than .2 in its reading from the rest should be discarded. As the capacity of the part of the neck over which the scale extends should be 2 c.c., the accuracy of the scale may be tested by filling the bottle to the zero mark with water. Remove any drops which may have adhered to the inside of the neck, with a piece of absorbent paper; then add 2 c.c. of water by means of a properly graduated pipette or burette. If the scale is correct the water will extend to the 10 per cent. mark.

16. Pipettes and acid measures may also be tested by measuring water from a graduated burette.

17. Care and exactness with regard to every detail are absolutely necessary in order to obtain reliable results in milk-testing.

COMPOSITE SAMPLES.

This method of sampling milk is employed in cheese factories and creameries where milk is paid for in proportion to the amount of fat delivered instead of in proportion to the weight of milk. The object of the composite sample is to obtain an average test of several lots of milk without involving the great amount of work which would be required to test each lot separately. A small sample is taken from the daily deliveries of each patron's milk and is placed in a bottle which contains a small amount of some kind of preservative. Several kinds of preservative are used for this purpose, but among the most common are Bichromate of Potash and Corrosive Sublimate; the latter is sometimes sold in tablets. Bichromate of potash is a good preservative if samples are not required to be kept longer than ten days or two weeks, but for longer periods it does not appear to be strong enough to give good results. On the other hand corrosive sublimate, which is a very violent poison, will preserve milk for a much longer period, but it is somewhat dangerous to use it alone, as it does not give any color to indicate that the milk contains poison. An excellent preservative can be made by mixing bichromate of potash and corrosive sublimate in the proportions of seven parts of the former to one of the latter. From what can be taken on a five cent piece to what can be taken on a ten cent piece will usually be found sufficient to preserve a pint sample from two weeks to one month. The amount of preservative required will depend on, the weather, the size of the sample and the length of time it is to be kept. At the end of this sampling period, which may be two weeks or one month, depending on various conditions, the sample may be tested with the Babcock test, and if all the work of sampling and testing has been carefully done the test should give the average percentage of fat in the different lots of milk which the sample represents.

NOTES ON COMPOSITE SAMPLING AND TESTING.

1. Pint bottles with close fitting stoppers are convenient for holding composite samples.
2. The bottles should be kept closely stoppered to prevent evaporation or absorption of moisture, also to prevent any foreign substance getting into the sample.
3. Paste a plainly written label on each patron's jar, and give it at least two coatings of shellac to prevent it from washing off when cleaning the bottles. Numbering may also be done by roughening a portion of the neck of the bottle with a file or whet-stone, then write the patron's number on with a lead pencil.
4. Add the preservative to the sample bottles before any milk is put in. It may be necessary to put in a little more later if the sample shows indication of spoiling. Too much preservative makes it difficult to dissolve the casein of the milk with sulphuric acid when testing, and also has a tendency to give burnt readings.
5. The sample for the composite jar should be taken after the milk is poured into the weigh can. For this purpose an ounce or half ounce dipper is often used. A tube or milk "thief," or a drip from the conductor pipe are also satisfactory means of sampling. It is difficult to accurately sample frozen milk, and patrons should be warned against sending milk in that condition.
6. Give the jar a gentle rotary motion each time a fresh sample is added, to mix the cream that has risen and the fresh sample with the part containing the preservative. Avoid shaking the jar as that has a tendency to churn the contents.
7. It is sometimes necessary to place the samples in a cool place each day when through using them.
8. To prepare composite samples for testing, place the bottle in warm water and bring the temperature of the sample to about 110 degrees F. to loosen the cream from the sides of the bottle and cause it to mix more readily with the rest of the sample. Mix well by pouring from one vessel to another before sampling. If a sample is slightly curdled it may be brought into solution by the addition of a small amount of powdered alkali before heating. When the samples have been put in the Babcock test bottles, they should be cooled to at least 60 degrees before adding the acid. Paying strict attention to this point will usually prevent burnt readings. Sulphuric acid appears to act more strongly on samples containing preservative; therefore it is advisable to add slightly less acid than for normal milk. When difficulty is experienced with burnt readings it is recommended to add the hot water to the samples at two different times, filling to the neck of the bottle the first time, and whirling for one minute, and then adding to about the 8 per cent. mark

the second time and turning for another minute. Best results in testing will be obtained by adopting a certain temperature for each step of the work and always adhering to these.

9. **COST OF ACID FOR TESTING COMPOSITE SAMPLES.** In a gallon of sulphuric acid there is sufficient for about 260 tests. Estimating the value of the acid at $3\frac{1}{2}$ c. a pound, the cost of the acid for a single test would be about one-quarter of a cent.

10. To find the correct average test of a can of milk, which is composed of the milk given by several cows, find the total pounds of fat and the total pounds of milk, multiply the pounds of fat by one hundred and divide by the pounds of milk. There is often a considerable difference between the correct average test as determined in this way and the average test got by adding the tests together and dividing by the number of cows.

CREAM TESTING.

The fat content of cream can be determined quite as quickly and as accurately, by means of the Babcock test, as the fat in milk. For this reason the Babcock test has largely displaced the slow and more laborious method of the Oil Test, in cream-gathering creameries.

For testing cream, special bottles, with graduated necks, large enough to contain 30, 40, or 50 per cent. of the weight of the sample in cream fat are used. The graduations on the bottle should be so arranged that readings to one-half of one per cent. can be made easily.

The proper sampling of cream is a very important part of the work. The same weight namely, 18 grams are required for a test. But since cream has a much less specific gravity than milk, due to the large amount of fat it contains, which is the lightest part of the sample, a 17.6 c.c. pipette will not deliver 18 grams into the bottle. Cream testing from 25 to 30 per cent. fat has a specific gravity similar to that of water. Therefore a pipette graduated to hold 18 c.c. is recommended for sampling such cream. Very rich cream, ripe or gassy cream, and cream fresh from a separator, can be more accurately tested by weighing the samples by means of a fine balance or special cream scale.

• Sour samples which contain lumps of curd may be prepared for testing by adding a little powdered alkali to the sample, and heating to 120 degrees F. When samples of viscous cream are taken with a pipette the results will be more accurate if a little water be used to rinse the pipette and the rinsings allowed to go into the test bottle.

No definite measurements of sulphuric acid can be given for testing cream as some samples seem to require more than others in order to give satisfactory results, but as a rule, slightly less acid is required for cream than for milk. A good guide as to the quantity of acid to use

is obtained by noting the color of the mixture of cream and acid when they have been thoroughly mixed. It should be a dark chocolate color, but not black. It is good practice to use a small quantity of acid first, and if the mixture does not turn sufficiently dark a little more may be added.

When a cream test is completed in the ordinary way, as indicated for testing milk, satisfactory results are not always obtained. Sometimes the fat appears in the neck of the bottle quite black or burnt, indicating too strong action of the acid. At other times the fat appears very light or cloudy indicating an insufficient action of the acid. The latter condition is usually associated with tests of rich cream, and the results are very unreliable as the comparison of the results of a few tests will show :—

Cloudy.	Correct.	Cloudy.	Correct.	Cloudy.	Correct.
Per cent. fat.	Per cent. fat.	Per cent. fat.	Per cent. fat.	Per cent. fat.	Per cent. fat.
42	39.5	46	39	40.5	36.5
40	38	41.5	39	37.5	35
43	38	43.5	40	38	36
42.5	32.5	44.5	40	44	38

These conditions can easily be prevented and clear readings of fat may always be obtained in making a cream test by following either of two methods :

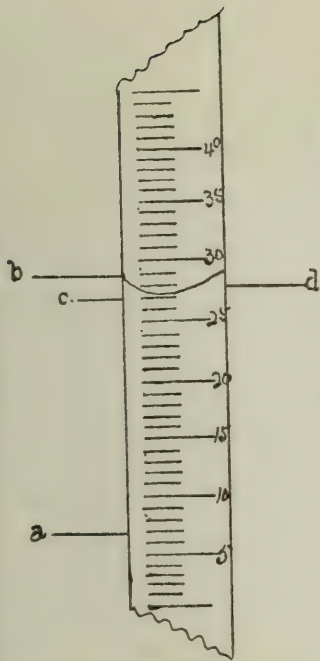
1. After the cream has been carefully measured into the bottle, a small amount, about one-third of a pipette of water, is added, and mixed with the cream before the acid is added. When 18 c.c. of cream is used for the test this rinsing of the pipette serves a double purpose, helping to make the test more accurate by causing all of the cream to be delivered into the bottle, and assisting in making a clear reading. Care must be taken that too much water is not added or a thorough mixture of the cream and acid cannot be obtained, and a test with light, curdy material at the bottom of the fat will be the result.

2. It has been found by experiment that very satisfactory results may be obtained by adding the hot water to the cream test as soon as the cream and acid are thoroughly mixed, and whirling the tester only once, from five to six minutes. This method has an advantage over the other in that it does not require so much time to complete a test, as the tester does not have to be stopped to allow hot water to be added. More accurate readings may also be obtained, as the meniscus of the fat is more clearly defined.

Cream tests should be read at a temperature of 140 degrees, and the fat measured to the bottom of the meniscus.

Errors due to expansion of fat amounting to one-half to one per cent. of fat, often exist when tests are read immediately after whirling in a steam tester.

The accompanying illustration shows the correct method of reading cream tests. Readings should be taken from *a* to *c* and not to *b* or *d*.



Composite samples of cream are made and cared for similar to those for whole milk, but the taking of samples for the composite bottles requires to be done with much greater care and accuracy. Owing to various and unavoidable causes, the weights and tests of the individual patron's cream varies considerably from day to day. Therefore it is necessary that the cream be carefully mixed and a sample be taken in proportion to the weight of each delivery.

Where cream haulers do all of the sampling it is somewhat difficult to carry out this principle, unless they are supplied with some special sampling instrument. It is suggested that a pipette graduated into small spaces, and nearly enclosed in a tin case to prevent breaking, be used for this purpose. The hauler would then receive instructions to take a space of cream for each pound or some definite number of pounds of each delivery.

Some creameries relieve the haulers entirely of the responsibility of taking proportionate samples, and only ask that they take a representative sample, then the proportionate sample is taken from this when it arrives at the creamery.

That the taking of proportionate samples is an important point is indicated by the fact that many large creameries in the United States have discarded the composite cream sample entirely, and are making tests of each individual delivery of cream, because they were unable to get reliable and satisfactory results from its use.

Cream samples are often sour when added to the composite bottles, and are more difficult to keep in nice condition than milk samples. For this reason it is advisable to use a stronger preservative, and a mixture composed of three parts of bichromate of potash and one of corrosive sublimate is recommended.

Composite cream samples should be carefully prepared for testing by heating to 120 degrees F. before sampling. If the samples are curdled a small amount of powdered alkali may be added to the bottle before heating.

When samples are in good condition and test over 30 per cent. fat, more accurate results may be obtained by weighing the test, and if creamery men insist on having a richer cream, it is only fair they should take the extra time and care required to weigh the tests.

The following results show a comparison of weighed and measured tests from monthly composite samples :—

Measured.	Weighed.	Measured.	Weighed.
Per cent. fat.	Per cent. fat.	Per cent. fat.	Per cent. fat.
17.5	18	29	29
18.5	19	29	29
20.5	20.5	29.5	29.5
21	21	29.5	29.5
22	22.5	29.5	30.5
24.5	24.5	30.5	31
27.5	27.5	33.5	34
28	29	34	35
28.5	29	36.5	37.5
37	38	41	42.5

THE OIL TEST.

This means of ascertaining the butter value of cream is still employed in a few sections. It is simply a churning process.

The cream collector is supplied with a pail 12 inches in diameter in which the depth of the cream supplied by the patrons should be carefully measured. After thoroughly mixing the cream the collector should take a representative sample, filling the test tubes carefully to the mark, which should be five inches from the bottom.

TO MAKE AN OIL TEST. Upon arrival at the creamery, set the samples in a warm place, as over the boiler, and leave over night to ripen thoroughly. They will not churn properly unless well ripened.

The next morning, place the samples in water at a temperature of about 90 degrees F., and as soon as the cream will flow freely from one end of the tube to the other, place in the oil test churn and begin churning. Should the cream at any time cool and thicken, place the samples in warm water to liquefy the cream again. Continue churning until there is evidence of a clear separation of the fat, then place the samples in hot water, at a temperature of from 160 to 170 degrees, for from fifteen to twenty minutes.

If the separation be complete, the fat will be clear and yellow, and there will be three distinct columns with sharp lines of division between them, viz., a column of clear fat on top, one of whey next, and one of curdy matter at the bottom. If there be not a clear separation, cool to about 90 degrees, churn again and proceed as before.

TO TAKE A READING. There is a chart prepared for the purpose. Place the bottle in an upright position on the "base line" of the chart, move it along until, when looking by the right side of the bottle, the

top of the column of fat comes even with the uppermost slanting line on the chart. Next still looking by the right side of the bottle, observe the line to which the bottom of the fat comes; the number on this line gives the reading.

A small rule made specially for this purpose is more convenient than a chart. This, however, will give a correct reading only when the test-tubes have been filled precisely to the mark. The chart consists of a sliding scale, and gives the proportion of oil regardless of the depth of cream taken or the diameter of the test-tubes.

Sometimes the fat, though clear, is somewhat open. In such cases, or when the fat is not clear, allow the samples to become cold, and then place in water at a temperature of about 120 degrees F. before taking a reading. About 120 degrees F. is a very suitable temperature at which to take readings.

MEANING OF THE READING. Cream that gives a reading of 100 in the oil test will make one pound of butter for every inch of such cream in a cream pail 12 inches in diameter; cream testing 120 will make 1.2 pounds of butter per inch. To find the pounds of butter, multiply the number of inches by the reading and divide by 100.

THEORY OF THE TEST. A standard or creamery inch is one inch of cream (in a 12 inch pail) testing 100.

One inch, therefore, contains 113 cubic inches. One pound of butter contains about 25 cubic inches of butter oil, which is 22 per cent. of 113. Therefore, any cream which will yield 22 per cent. of its volume in butter oil will yield one pound of butter per inch. Tubes filled to the depth of five inches with cream which gives 1.1 inches of butter oil will yield one pound per inch, as 1.1 is 22 per cent. of 5.

A reading of 100 by the oil test would, therefore, theoretically, be equal to 22 per cent. of fat.

SKIM-MILK, BUTTERMILK AND WHEY.

As the percentage of fat in skim-milk buttermilk and whey is usually very small, the best method of testing these is by the use of the double neck test bottle. There are several different kinds of double-neck bottles in use, but those having the two necks joined together, and extending perpendicularly from the center of the bottle, seem to give best results, as they are much stronger and less liable to give burnt readings.

17.6 c.c. of skim-milk, buttermilk, or whey are taken into a test bottle and the test is completed in the usual way. Very fine readings can be taken, as a small amount of fat can be made to extend over a long space in the small neck. Considerable difference of opinion exists amongst authorities on milk testing with regard to the correct method of reading the double-neck bottle; but chemical analyses indicate that the addition of .05 to the Babcock reading would give the most accurate results.

The fat column in the small neck can be raised or lowered slightly to assist in getting accurate readings by pressing the finger gently on the top of either neck.

It is recommended to use a little more than 17.5 c.c. of acid in testing skim-milk; also to turn the tester a few revolutions faster per minute, and whirl for a longer time. Whey does not contain such a large per centage of solids as milk, and usually about 10 c.c. of acid are sufficient to cause a clean separation of fat.

The whole-milk bottle is not suitable for testing skim-milk, butter-milk, or whey, as it is almost impossible to make an accurate reading of such a small amount of fat when it is extended over a broad surface. However, the milk test bottle might be used to indicate whether or not much fat is being lost.

TESTING CHEESE FOR FAT.

1. Obtain a representative sample by cutting a slice from the outside to the centre of the cheese, or by taking plugs from different parts.
2. Cut the sample as finely as possible and weigh 5 grams into a milk-test bottle or 9 grams into a cream bottle.
3. Add sufficient warm water at a temperature of 120 degrees F., to make about 18 grams in the bottle.
4. Keep the sample warm and mix occasionally, until the cheese and water form an emulsion.
5. Measure 17.5 c.c. of acid. Add a little at a time and continue mixing until the curd is all dissolved.
6. Sometimes, slightly more than 17.5 c.c. of acid are required for a test. Sufficient has been used when the mixture turns a dark chocolate color.
7. The hot water may be added before whirling in the tester.
8. To find the per cent. fat., multiply the reading by 18 and divide by the number of grams used. For example: 5 grams give a reading of 8.5, the percentage of fat in the cheese = $\frac{8.5 \times 18}{5} = 30.6$.

THE LACTOMETER AND THE DETECTION OF ADULTERATIONS IN MILK.

The lactometer is an instrument used to determine the *specific gravity* of milk. The term specific gravity means the weight of a certain volume of any substance compared with the weight of the same volume of pure water at a standard temperature.

There are different kinds of lactometers, but the Quevenne is the most suitable for milk-testing. By means of it we can determine rapidly the relative weights of milk and water.

The Quevenne lactometer is standardized at a temperature of 60° F.; if the milk to be tested varies from this, corrections may be made

according to the following rule: For each degree in temperature *above* 60, add .1 ($\frac{1}{10}$) to the lactometer reading, and for each degree *below* 60, subtract .1 ($\frac{1}{10}$) from the lactometer reading. This rule is practically correct, if the temperature is kept within a range of from 50° to 70° F. It can be readily recalled when we remember that the density of milk *increases* with a *reduction* of temperature and decreases with a rise in temperature. The scale on the lactometer is graduated from 15 to 40, and indicates a specific gravity of from 1.015 to 1.040.

Note. The correct lactometer reading (or L.R. at 60° F.) + 1,000 ÷ 1,000 indicates the specific gravity.

The lactometer reading of whole milk usually ranges from 29 to 34, although it may fall as low as 27, or go as high as 35. The lactometer reading of skim-milk varies from 33 to 38. The reading should be taken soon after placing the instrument in the milk; if cream be allowed to rise on the milk, the reading will be too high, as the bulb of the lactometer will be floating in partially skimmed milk. Milk should be cooled and allowed to stand some time (one to three hours) after being milked before taking the lactometer reading. Otherwise the readings will be too low.

The composition of milk is about as follows:

Fat	3.6	per cent.		
Casein	2.5	"	} 8.9	solids not fat.
Albumen	.7	"		
Sugar	5.0	"		
Ash	.7	"		
Water	87.5	"		
100.00				

It is the solids not fat in milk that cause its specific gravity to exceed that of water and consequently its lactometer reading to be greater, as the percentage of solids not fat increase.

A number of different rules have been prepared for the calculation of milk solids when the lactometer reading and the percentage of fat are known. Of these, the following has been quite generally adopted. To find the per cent. of solids not fat in a sample of milk, add two-tenths of the per cent. of fat to one-quarter of the lactometer reading; and to find the per cent. of total solids add one and two-tenths times the per cent of fat to one-quarter of the lactometer reading.

The following rule also is sufficiently accurate for practical purposes and has simplicity to recommend it. To determine the per cent. solids not fat, add the lactometer reading at 60 degrees and the per cent. of fat together and divide by four (4). Example: L.R. = 32,

$$\text{Fat } 4\% \frac{32 + 4}{4} = 9\% \text{ S.N.F.}$$

ADULTERATIONS.

By the use of the Babcock test in conjunction with the lactometer, we are enabled to determine both the nature and the extent of an adulteration.

The percentage of fat in milk varies and can also be influenced by skimming, therefore the lactometer alone is of little use in determining adulterations. The solids-not-fat are fairly constant and thus afford a means of detecting adulterations.

Watered Milk. To find the per cent. of pure milk in a watered sample, multiply the per cent. S.N.F. in it by 100 and divide by the per cent. S.N.F. in the pure milk. This subtracted from 100 will give the per cent. of extraneous water in the watered sample. To take an example :

The per cent. of solids-not-fat in a sample of pure milk is 9; but after being watered the per cent. of solids-not-fat in the watered sample is 7.2. Find the per cent. of pure milk in the watered sample.

Per cent. of pure milk in watered sample, $\frac{7.2 \times 100}{9} = 80$ per cent.

Per cent. of extraneous water = $100 - 80 = 20$ per cent.

Note. When a sample of pure milk cannot be obtained, use 8.5 in the early part of the season, and 9 in the later part, for the per cent. S.N.F. in pure milk.

The per cent. of *water added to the pure milk* may be estimated as follows : The per cent. S.N.F. in a pure sample, multiplied by 100, divided by the per cent. S.N.F. in the watered sample, less 100. The above may be worked out as follows :

$\frac{9 \times 100 - 100}{7.2}$ equals 25 per cent. water added, or

To 80 lbs. pure milk, 20 lbs. water were added, then to

1 lb. pure milk, $\frac{20}{80}$ lbs. water were added.

To 100 lbs. pure milk, $\frac{20}{80} \times \frac{100}{1}$ lbs. water were added,

equals 25 lbs. water added to 100 lbs. milk, or 25 per cent.

NOTES.

1. Have the temperature of the milk uniform throughout, and as near 60° F. as possible when taking a lactometer reading.

2. Always mix the milk well before taking a lactometer reading.

3. Do not have milk on the upper part of the stem of the lactometer when reading, as this weighs the lactometer down and causes the reading to be too low.

4. Have the lactometer free from the side of the vessel, and perfectly still when taking a reading.

5. A high lactometer reading accompanied by a low per cent. of fat indicates skimming, e.g., L. equals 34, F. equals 2.4.

6. A low lactometer reading accompanied by a low per cent. of fat is indicative of watering, *e.g.*, L. equals 22, F. equals 2.4.

7. A normal lactometer reading with a very low per cent. of fat indicates both watering and skimming. Also, if the lactometer reading of a sample of milk be low, yet not so low accordingly as the per cent. of fat, this is indicative of both watering and skimming. Both of the following indicate watering and skimming; L. equals 31, F. equals 2; L. equals 26, F. equals 1.8.

THE HART CASEIN TESTER.

This is a simple test for determining the casein content of milk. The test has been introduced by Dr. E. B. Hart, of the Wisconsin Experiment Station, and its development and use is likely to prove of considerable value to the cheese branch of the dairy industry. No more ability or skill is required to make a casein test than is necessary in making a Babcock test for fat and the test can be completed in a few minutes.

The principles involved in this method as outlined by Dr. Hart are :

1. The construction of a special bottle with a graduated scale whereby the percentage of casein can be read when a definite volume of milk is used for a test.
2. The precipitation of the casein by dilute acetic acid.
3. The agitation of the precipitate with chloroform to dissolve the fat.
4. The application of a definite centrifugal force in order to mass the casein into a pellet.
5. Reading the per cent. of casein.

The details connected with a determination of casein are briefly as follows :—

1. Measure 2 c.c. of chloroform into the test bottle.
2. Add to this 20 c.c. of a .25 per cent. solution of acetic acid at a temperature of 70 degrees F.
3. Measure accurately 5 c.c. of sweet milk at a temperature of 70 degrees.
4. Place the thumb over the opening of the bottle, turn the bottle over by rotating the hand and shake the contents vigorously for fifteen to twenty seconds.
5. Place the tests in the centrifuge and whirl for $7\frac{1}{2}$ to 8 minutes at a speed of 2,000 revolutions per minute for a 15 inch diameter machine.
6. After whirling, allow the tests to remain for ten minutes to allow the pellets to relax slightly, before taking the readings.

NOTES ON THE CASEIN TEST.

1. Use only the best quality of chloroform.
2. See that the temperature of the milk and acid are as nearly 70 degrees F. as possible.
3. Use a watch to take the time in shaking the test and do not mix more than 20 seconds.
4. Make sure that the speed of the tester is correct. It is advisable to use a metronome for this purpose when the whirling is done by hand power.
5. Curdled samples of milk cannot be tested for casein.
6. Composite samples preserved with bichromate of potash for from three to four days can be tested more or less satisfactorily, but samples containing other preservative and those with bichromate of potash which are kept for a longer time, do not appear to give reliable results. Therefore, the test will need to be improved in this particular before it will be suitable for factory conditions.
7. A comparison of the results of the Casein Test with those of chemical analysis, conducted at the Ontario Agricultural College during the summer of 1908, shows the casein test to be quite accurate. The average percentage of fat in 22 samples of sweet milk was 3.72. The average percentage of casein in these samples as determined by the Hart method was 2.395, and by chemical analysis 2.415—a difference of only .02 per cent.

CHEESE-MAKING.

BY ALEX. MCKAY AND C. H. RALPH.

CARE OF MILK.

Milk is the raw material from which the cheese or butter maker manufactures a valuable and concentrated food product. It is a perishable article and very susceptible to contamination; it should be supplied only from cows in good health, furnished with an abundance of wholesome food, pure water and having free access to salt at all times. Cows giving milk should not be allowed to eat turnips, rape, foul, weeds, musty or decayed food, or anything that will impart an objectionable flavor to the products, as injury to the milk from any cause results in a positive loss to the producer. It is very important that there be no dust or bad odors in the stable at the time of milking. Before commencing to milk, the udder and flank of the cow should be brushed or wiped with a damp cloth to remove loose hairs or fine particles of dust or filth as these are usually laden with undesirable germs. The milker should be clean, kind and sympathetic and free from any contagious diseases. Use

only tin pails, being careful to see that all seams are well soldered so as to facilitate cleaning. Wash and scald thoroughly all utensils used in handling milk. First rinse them with water, then wash well with water at a temperature of about 120° F., and then scald or steam. Do not wipe with a cloth, but place to drain where they will get plenty of sunlight and pure air. Use a brush in preference to a cloth for washing tinware. If these few simple rules are followed we should be able to produce milk in a fairly clean condition, and clean milk means milk with a comparatively low bacterial content. But, be as careful as we may, we find that we are unable to produce milk which is free from germ life, so the next step is to employ means of keeping this life in check. The only practicable way is to reduce the temperature so as to make unfavorable conditions for its development. The simplest and most effective way of doing this is to provide a tank large enough to contain cans that will hold at least two milkings. Before commencing to milk, this tank should be filled with cold water into which the empty cans are placed, and as each cow is milked the milk should be strained into the cans. By handling the milk in this way the cooling is practically done as soon as the milking is completed. The milk should be covered up as soon as possible to prevent contamination from the surrounding atmosphere, and sufficient cold water added to the tank to reduce the temperature of the milk to at least 65° F. and for keeping it at that temperature over night. If keeping milk over Sunday cool to 55° F. and hold at that temperature. This tank may be so arranged that all the water pumped for watering stock may be run through it before it reaches the stock-watering trough thereby saving the labor of pumping this extra amount of water. Ice is almost a necessity for keeping Saturday night's or Sunday's milk. The warm milk should in no case be mixed with that already cooled. Where possible send to the factory in separate cans. If this is not done, the morning's milk should be cooled before mixing with the evening's milk. The whole secret of keeping milk in good condition is to be found in cleanliness and low temperature and under no conditions should chemicals be used for preserving milk.

THE CURD TEST.

Provide tin or porcelain cups sufficient in number to test the milk of at least the number of patrons supplying milk to the factory. A convenient size is two inches in diameter and three inches deep. Each cup should be plainly numbered. Provide a box of tin or galvanized iron with a neat fitting cover, large enough to hold the cups. For convenience; this box should have both water and steam connections. In taking the samples for making the tests place the number of the cup opposite the patron's name from whose milk the sample was taken. Place them in the box already described, adding water to the depth of the milk in the cups. Raise the temperature of the samples to 86° F.

Set the samples by using one dram of a dilute rennet solution made of a strength of one part rennet to twenty-four of water. Stir in the rennet with a knife having a solid metal handle being careful to sterilize the knife between the stirring of each sample so as not to contaminate one sample with flavors from another. When firm enough, cut with the same knife using the same precautions to sterilize between the cutting of each sample. Raise the temperature gradually to 98° F. and handle the sample as nearly like the milk and curd in the vat as possible. If looking for "bitter" flavors and the milk is in a sweet condition, it may be advisable to add a few drops of culture to the samples before setting, as this flavor is rarely detected without acid. This test is particularly valuable in detecting flavors which develop in the curd but cannot be detected in the milk. It is also valuable for convincing patrons who may doubt that the flavor of their milk is as bad as represented by the cheesemaker, as it is possible to have them see and smell the curd made from each patron's milk as delivered at the factory.

THE PREPARATION AND USE OF A CULTURE.

A culture for cheese-making is now looked upon as a necessity, therefore the need of full and exact knowledge of the proper method of preparing and using cultures. First provide suitable cans of good tin, which are well soldered, and about twenty inches deep and eight inches in diameter. It is better to have a duplicate set, as this gives a better opportunity for keeping them in good condition. When the milk is in small lots it can be more readily heated and cooled than if kept in larger quantities. For convenience in heating and cooling, a special box large enough to hold the cans containing the culture for one day's use should be provided. This should have cold water and steam connections. The cans may be left in this box so as not to be influenced by the outside temperature. In starting a culture it is advisable to use a commercial or pure culture. These may be obtained from the Bacteriological department of the College or from any of the dairy supply houses.

Special temperatures are required for the first propagation of these Commercial Cultures.

Empty the mother culture into a quart of pasteurized milk cooled to a temperature of 75° to 80° F. and allow to stand until coagulation takes place.

It is advisable to propagate commercial cultures at least two or three times before using them.

Better results may be obtained by using the milk from the same source each day, as we are more likely to get a uniform flavor and acidity from day to day by so doing.

After selecting the milk for culture, heat to a temperature of 185° F., then cool rapidly to a temperature of 60° F. To this milk add enough of the culture already prepared to develop an acidity of not more than .7 at the time the culture is required for use.

If the culture is to be kept more than 24 hours it is advisable to set accordingly by using a lower temperature and using less of the mother culture. Aim to produce the same acidity from day to day.

Before using, remove one or two inches of the milk from the surface of the can, as this is more liable to contamination from outside sources. Break up the remainder by stirring well in the can.

At this time take out a small quantity to propagate the culture for the next day. A glass sealer should be provided for this purpose.

The indications of a good culture are as follows: The whole mass is firmly coagulated, no liquid is found on top, it has a mild acid flavor, pleasant to the taste and smell.

A culture may be used to advantage when the milk is maturing slowly or when it is tainted or gassy; one half of one per cent. is the greatest quantity that should be used, and this only when the milk is known to be in a sweet condition.

Milk should be set slightly sweeter when culture is used.

With gassy milk its use is especially beneficial.

Culture with bad flavor or with too high an acidity should not be used.

A wire handled dipper is preferable for stirring milk for cultures.

All utensils must be thoroughly cleaned and sterilized after each time of using.

CO-OPERATION BETWEEN MAKER AND PATRONS.

That there has been a marked improvement in the milk delivered to the factory for cheese-making is quite apparent from the improved quality of the cheese produced, but there is still room for more co-operation between the maker and his patrons; first by the maker keeping his factory and its surroundings in a better condition as to cleanliness and sanitation thereby making it a more attractive place, which the farmer can look at with pride instead of disgust; secondly by returning the by-product, whey, in better condition. This latter can be accomplished only by the pasteurization of the whey and the proper cleaning of the tank. It is useless heating the whey unless it is all removed each day and the tank thoroughly washed.

We cannot advise any particular method of heating as this must be varied according to the conditions at the factory, but the heating should commence as soon as the first whey is run into the tank. This should be done for two reasons:—first, to take advantage of the temperature the whey is already at; and second, to prevent the further development of acidity.

The whey should be heated to at least 150° F. in order to obtain the best results. Care should be taken not to exceed 160° F. as heating above this temperature will cause the whey to become slimy.

MILK FOR CHEESE-MAKING.

To obtain the best results, it is necessary to have the milk delivered at the factory clean, sweet, and of good flavor, and we would strongly advise cheese-makers to reject all milk which is not in a fit condition for the manufacture of first-class cheese. The maker who receives milk other than of this kind is acting dishonestly towards his better patrons who are furnishing a first-class quality of milk.

TESTING FOR RIPENESS.

This may be done with the acidimeter or the rennet test;—good results may be obtained by the use of either test.

No definite degree of acidity can be given as a rule to go by. The proper rule is to set at the acidity that will give the best results later in the process or will allow the curd to remain in the whey until properly "firmed," which will usually take from $2\frac{3}{4}$ to 3 hours from the time of setting to the time of dipping the curd with the right amount of acid developed. This will be found to be slightly less than the acidity of the milk at setting as shown by the acidimeter.

If using the acidimeter and making colored cheese, the acidity should be ascertained before adding the color to the milk, as it is more difficult to detect the neutral point with the color added.

Another point to note carefully when using the acidimeter is the effect of the presence of rain water in the milk. When the milk is diluted, less milk is taken in the sample, and will show a less degree of acidity than is contained in the milk to the extent of the percentage of dilution, thereby misleading the operator.

If color is used it should be thoroughly mixed with the milk before the rennet is added, using one to one-and-one-half ounces of color per thousand pounds of milk. Add color in amount as the market may require.

When making early spring cheese it is usually necessary to make a quick-curing cheese in order to reach an early market.

To make this class of cheese it is advisable to use a large quantity of rennet and a small quantity of salt, as this hastens the ripening process and overcomes the tendency of milk at this time to make a dry, hard cheese due to the low per cent. of butter-fat in the milk and the tendency of this class of milk to develop acid rapidly. Heat the milk to 86° F. and stir slowly while heating. When the desired acidity is obtained, add the rennet, using four to five ounces per thousand pounds of milk or sufficient to coagulate the milk firm enough for cutting in fifteen or twenty minutes.

Commence to cut early, using the horizontal knife first, cutting slowly lengthwise of the vat.

Then with the perpendicular knife cut crosswise and afterwards lengthwise of the vat. We would advise strongly the use of the $\frac{1}{4}$ -inch wire knife as this leaves the curd in better condition for the moisture to escape with the least possible loss in the whey, as the cubes are smaller, and more uniform and are not so easily broken as the larger ones.

Commence stirring at once with agitators or the McPherson rake. Stir carefully for ten or fifteen minutes, then see that the curd is free from the sides of the vat before applying heat. This loosening of the curd from the sides of the vat can be done at this stage with less loss than if done immediately after cutting, as the curd has become somewhat firmer and does not break up so readily. Curds should be handled carefully and in such a manner that the cubes will not be broken, nor allowed to mat together. Rough handling or breaking of the curd causes a serious loss to both quality and quantity.

Heat to a temperature of 98° F. in $1\frac{1}{2}$ hours from the time of setting. We formerly advised taking the agitators out soon after heating was completed with the idea that we were able to firm the curd better with the small rake, but since the introduction of the $\frac{1}{4}$ -inch knife, we have found that we get better results, with less labor, by allowing the agitators to run for a longer time.

We still advise removing part of the whey so as to guard against the danger of a rapid development of acid at the time of dipping, as the curd can be removed more quickly with a small amount of whey. This can be accomplished by removing one of the paddles until the whey is reduced; then replace the paddle and allow the agitators to do the stirring, as they do it more gently and with less danger of harming the curd. There is nothing gained by harsh treatment of the curd, as such treatment will allow the moisture to escape only in so far as it breaks the curd. It is much better to allow the curd to firm by natural agencies, namely, acid development, heat, and rennet action. Acid usually develops very rapidly in the spring, therefore it is necessary to be prepared to remove the whey quickly when sufficient acid has been developed, which may be from .165 to .19 per cent. as shown by the acidimeter. Curds at this stage should be nice and firm (not hard or harsh), and be kept in a loose, open condition in the sink a sufficient length of time to allow the free moisture to escape, as the moisture can be removed at this stage with very much less loss than it can later on. Leave the curd about 8 inches deep in the curd sink. When it is well matted, cut into strips 6 to 8 inches wide and turn upside down, and in about fifteen minutes turn again, piling two deep. Continue turning every fifteen minutes until the curd is ready to mill. When the curd is well matted and flaky and shows .7 to .8 per cent. of acid it should be milled, and well stirred afterwards. The stirring should be repeated often enough to prevent the curd matting until ready to salt. This will be when the curd has mellowed down nicely and shows 1 to 1.2 per cent. of acid. Stir and air the curd well before adding the salt, as this improves the texture and

flavor of the cheese. Salt at the rate of $1\frac{1}{2}$ to 2 pounds of salt to 1,000 lbs. of milk. It is important that the temperature of the curd from dipping to milling should not go below 94° F. After milling, allow the curd to cool gradually to about 85° F. when ready to salt. Put to press at a temperature of 82° to 84° F. Weigh the curd into the hoop, tighten the press gradually and leave the cheese 45 minutes before taking out to dress. When dressing, use plenty of clean hot water and what are commonly called "skirts." These cloths help to make a good rind on the cheese, keep them clean, and cause the cheese to come out of the hoop more readily. Turn all the cheese in the hoops every morning, and allow no cheese to be taken to the curing-room that do not present a clean, neat appearance.

SUMMER CHEESE.

In making summer cheese one ounce of color to one thousand pounds of milk is usually sufficient, but this may be varied according to the requirements of the market. Use from 3 to $3\frac{1}{2}$ ounces of rennet extract per thousand pounds of milk, or sufficient to coagulate the milk for cutting in 25 to 30 minutes. If this limit is exceeded we have too great a loss in the whey. The cutting and firming of the curd is the same as given for spring cheese.

It may be necessary to raise the cooking temperature slightly higher, as we may be dealing with milk of a different composition from that used in the spring. The acidity should be allowed to develop to such a point that is found from day to day to give the best results in the working of the curd later in the process, aiming to have the curd with good body, well matted and in a flaky condition when ready to mill. At this time it should have an acidity of .7 to .8 in about two hours from the time of dipping. The curd should be well stirred after milling, and, if cut crosswise of the grain, the stirring may be done better and with much less labor. Curd should be well matured, stirred, aired thoroughly and cooled to a temperature of 85° F. before salting. Use from 2 to $2\frac{1}{2}$ pounds of salt on the curd from one thousand pounds of milk.

FALL CHEESE.

When making fall cheese it is a mistake to use too much culture or to ripen the milk too much, giving the cheese the appearance of having been made from over-ripe milk, which is very objectionable in fall cheese; rather use a smaller amount of culture, not more than one-quarter of one per cent., and add it to the milk when there is a small quantity in the vat, as it starts a gradual fermentation which continues all through the process. Always heat the milk to at least the temperature of the culture before the culture is added. Set slightly sweeter than usual, as we are able to work closer to the "sweet line" all the way through, owing to the fact that we receive the milk in a better condition.

GASSY MILK.

The presence of gas in the milk retards the development of acid, and as acid is necessary in the manufacture of cheese we should make the condition as favorable for its development as possible without injury to the body of the curd. To do this, use $\frac{1}{4}$ to $\frac{1}{2}$ per cent. of good culture, as by so doing we introduce into the milk an abundance of the lactic acid bacteria which will, under favorable conditions, overcome the gas producing bacteria.

The next step is to ripen the milk slightly more than usual before setting. When cutting, aim to have the cubes as even in size as possible. Allow the acid to develop slightly farther before applying the heat, stir carefully, and heat slowly, aiming to have the curd in normal condition at dipping. Use the same temperature for cooking and the same acid for dipping as with a normal curd. A gassy curd does not require so much stirring as a normal curd, because the moisture leaves it more readily. Mill as soon as the curd is well matted and the acidity has developed to .8 to .85 per cent. About half way between milling and salting commence piling the curd. Allow it to stand 15 or 20 minutes then spread it out, stir and pile again. Continue to do this until the curd feels mellow. Give plenty of fresh air before salting. Use a normal amount of salt and put to press at a temperature of about 80° F., if possible.

OVER-RIPE MILK.

What is over-ripe milk? It is milk with one of the agents used in cheese-making out of proportion; or milk with the lactic acid developed in too great a degree in order to obtain the very best results in converting the milk into cheese. What are the agents used in separating the solids from the moisture or water content of the milk? They are rennet, heat, and acid development, together with the cutting of the curd to get it into a convenient condition for the escape of the moisture. The heat should not be applied until enough milk is in sight to fill the vat. Why? Because as we raise the temperature, we make more favorable conditions for the development of acid. Heat as quickly as possible to 82° or 83° F. and after testing for acidity set at this temperature. Why? Because, first, 82° is less favorable for acid development than 86° F., and the time for heating to 86° is saved; and what is more important, you are able to get the rennet in sooner and a larger quantity of it, thereby getting the acid under control more quickly; if not under control, it is difficult to get it to work in conjunction with the other agents which contract and expel moisture from the curd. In handling over-ripe milk we think it is always advisable to use more rennet—at least one ounce more, per thousand pounds of milk, for several reasons: first, that it may coagulate the milk more quickly; second, it gives a firmer curd more quickly, and renders the curd less liable to be broken when

handling it, thereby saving to a great extent the great loss which usually is sustained from making over-ripe milk into cheese. It also helps to break down the caseous matter in the cheese, giving it a better texture. Commence cutting the curd early and cut rapidly so as to keep pace with the rapid firming of the curd. If this is not done the curd will get into a condition which makes it very hard to cut properly. Use the $\frac{1}{4}$ -inch knife rather than cut the curd four times, as it leaves the curd more uniform and in better condition than when it is chopped finely. Heat quickly, and if necessary, raise the temperature two or three degrees higher than for normal milk.

Here is where a great many cheese-makers make a mistake, by stopping the stirring and running off part of the whey when the curd is quite soft; while the whey is running off, the curd is matting, then they go at it with the little rake and break it all up, thereby liberating a lot of the milk solids, giving them a high acid reaction in the whey, and the result is, they have a sweet curd and a sweet cheese. Just stop and think for a minute which is likely to do the more effectual work, you with a rake, or the acid development in conjunction with the heat and rennet action? The natural tendency for this kind of curd is to run together, so the best way is to keep it stirred in all the whey until it firms up a little. Hard raking does not firm the curd, except in so far as it breaks the cubes. If agitators are used, the curd can be kept apart and the whey lowered quite soon enough without resorting to this rough handling. One can readily see that if the whey be lowered quite close to the curd while it is in a soft condition that it will be quite difficult to keep it from matting; and while you are keeping it apart with a small rake, you are breaking it up, causing a loss, and also causing rough texture in the cheese. It is always advisable to have the whey run down shortly before the dipping point is reached to avoid being caught with too much acid. When the curd is in a soft condition it is advisable to dip with slightly less acid and to keep it in a loose open condition in the curd sinks until all the surplus moisture is drained from the curd. If the curd is still a little weak, mill slightly earlier than usual. If not, treat as a normal curd. Mature the curd well before salting.

RIPENING OR CURING CHEESE.

The ripening or curing of cheese is one of the most important points in the process, as no matter how well a cheese is made, if the curing is not properly done the quality cannot be the finest. Therefore it is necessary to provide a room where the temperature can be controlled at all times. It is important some means be provided to control the moisture in the room so as to prevent the growth of mold which occurs where too much moisture is present. An excessive shrinkage takes place if there is too little moisture in the room. Proper temperature and moisture may be obtained by building an ice chamber in connection with the curing

room and having a free circulation of air over the ice. This cools the air and causes a deposit of the moisture on the ice. In putting the cheese in the curing-room, place them straight and even on the shelves and turn them every morning except Sunday. Keep the room well swept and looking clean and tidy. Use good strong cheese-boxes, have them dry, and of such a size as to fit the cheese nicely.

Weigh carefully, and stencil the weights neatly on the boxes. Load the cheese on clean wagons, and provide canvas covers to protect them from rain and heat while on the way to the station.

SEPARATORS AND THE SEPARATION OF MILK.

R. W. STRATTON.

In dealing with this subject, general directions only can be given. Space will not permit giving detailed directions for the different makes of separators. A book of directions is furnished with each new separator sent out, and the specific instructions contained therein should be strictly followed unless you know of something better, which you have proven to be so by practice, not theory. Separators may be divided into two classes—the steam or turbine, and the belt separator.

TURBINE SEPARATOR.

In setting it up, a solid foundation should be provided. It does not matter how solid a wooden floor is, it will vibrate more or less from the running of a churn or other machinery. With a stone, brick, or cement foundation a separator is independent of any vibration from other machinery and will run much better, and for a longer time. If setting the separator on a cement floor probably the most permanent method of fastening it down is as follows: First mark the exact location for the holes. With a square draw a line through the centre where the holes should be, then drill the cement to the desired depth (6 to 7 inches). To do this a common cold-chisel may be used providing the bit is wide enough for the body of the chisel, though a pointed chisel for this purpose is preferable. The dust may be removed from the hole while drilling by a small bellows, or blowing through a small rubber or glass tube. Have the bolt head somewhat rounded and place the bolt in the hole with the threaded end up, making sure to have it perpendicular and in line, and the necessary height above the floor, then pour melted lead in the hole around the bolt. If a method is desired whereby the bolts can be removed from the floor, drill holes as above, plug with wood, bore with a bit at least $\frac{1}{8}$ of an inch smaller than the lag screws used and fasten down with lag screws. Another method whereby separators may be changed without drilling new holes is to drill the holes in the cement nearer to the centre than any separator will be likely to require, fasten a 2 inch by 4 inch piece of wood to the floor and bolt the separator to it.

In putting down a cement floor to be used for separators, it is well to have a pier built about two inches higher than the floor and about the size of the separator base. This tends to prevent dirt from lodging under the separator when scrubbing the floor.

If a stone or brick pier (bricks are neatest) has to be built, the nature of the soil will determine the depth to excavate, and the size of the frame or base of the separator will determine the length and breadth. The exact specifications are given in the book of instructions furnished with the separator.

Place the separator in position, being careful to have the separator frame perfectly level every way. Determine this by placing the spirit level upon the planed top of the frame.

The pipe to convey the steam to the separator may be the same size as the fittings of the separator, provided the distance from the boiler is not over twenty-five feet. When the distance is more than this, the size of the pipe should be one-quarter inch larger for every twenty-five feet of piping, to overcome the effects of friction and condensation of steam.

Exhaust pipes are usually made of galvanized iron, and should never be reduced in size at any point smaller than the outlet on the separator, and should be put up as straight as possible to convey the steam from the separator. It may be carried out at the side of the building. In either case, a piece extending upwards should be put up to cause a draught. Placing the exhaust pipe out through the roof is preferable when the surroundings will permit it. Have the pipe long enough to be higher than any part of the roof, in order that the draught may not be interfered with by change of wind. A drain pipe must be provided in any case at the lowest point on the pipe, to allow water to escape readily. If this should be in the making-room, a trap to prevent annoyance from escaping steam may be put on the drain pipe.

BELT SEPARATOR.

The directions given for the foundation of a turbine will apply to this. First place the intermediate or jack in position. This should be at an angle of at least 45 degrees in front or behind the driving shaft. Level it by placing a level perpendicularly on the planed rim of the separator pulley of the intermediate. Be sure to have the shaft of the intermediate parallel with the driving shaft.

The pulley provided for the driving shaft should be of sufficient width to allow the belt to be shifted from the tight to the loose pulley of the intermediate, and of the proper size to give the exact speed required.

Next place the frame of the separator in position. Level it in all directions by placing the level on the planed top of the frame. Line the separator with the intermediate, so that looking from the intermediate the right hand edge of the small pulley of the separator is in line with the right side of the large pulley of the intermediate, having the vertical centre line of the spindle level with the underside of the intermediate pulley.

The separator bowl should revolve to the right, or with the sun, the same as the hands on a watch. The intermediate should run from the separator, so as to place the draw belt on the upper side of the intermediate pulley, with a view to remove some of the weight of the bowl from the foot-step bearing when the separator is running. If an idler or belt-tightener is used, always place it on the "return" side of the belt—*never* on the "draw" side.

Do not use the belt tightener any more than is absolutely necessary, as it shortens the life of the belt very materially. It would be an improvement if the intermediate could be adjusted to suit the stretching of the separator belt.

Wipe all the bearings well with a cloth, to remove all grit and dust. A little coal oil upon the cloth will be found helpful where any coating of dried oil is met with. See that all oil tubes are clear and free to feed oil. Wash the bowl and all parts that the milk comes in contact with. If everything has been properly attended to as directed it is ready to start. If a turbine, turn on steam very gradually to allow the water to get out of the steam pipes, when the required amount of steam may be turned on. When speed has been reached, start the feed of milk.

If a belt machine, and only one in use, put all belts in position, and start the engine slowly, allowing the speed to increase gradually. If more than one separator is used, it is better to start the engine at full speed, then shift the belt from the loose to the tight pulley after starting the separator by pulling the belt with the hand until the bowl has attained some speed. Then shift the belt from the loose pulley part way on to the tight pulley, moving it at intervals until on full. From 6 to 10 minutes should be required to get up speed. Full speed is ascertained by means of speed indicators. A 100 notch wheel should be counted for one minute, and a 50 notch wheel for one-half a minute, in order to know the number of hundred revolutions the bowl is revolving per minute. After speed has been reached, the milk should be turned on full speed, until both cream and skim-milk flow from the respective spouts; then it should be closed off until the cream is of the desired thickness. The cream should be the guide in operating the separator.

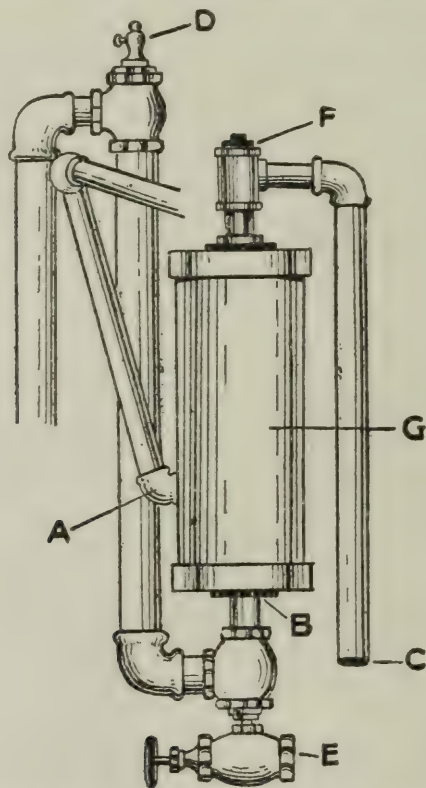
The cream left in the bowl when all the whole milk has been put through should be forced out with warm water. From one to two pails will be needed for this purpose. Shut off the feed-tap for a few seconds when about half the quantity has gone through; then turn it on again, allowing the remainder to complete the operation. Pure warm water is preferable to skim-milk, as it is nearer the specific gravity of the cream, and consequently displaces it more readily.

Allow the bowl to stop of its own accord after the power has been removed; never apply any brake or friction to the intermediate. Remove the solid matter found at the extreme outside of the bowl and burn it at once. Clean out all milk tubes with the spiral provided; wash with tepid

water thoroughly; scald with steam or boiling water; then place on a draining rack where the bowl and its parts may dry. Never close the bowl when wet inside, as it will cause it to rust. Leave it open when not in use so it will be thoroughly dry.

In ordering the parts for the separator always specify exactly what is wanted by the use of the proper name and number of the same. This can be found by consulting the book of instructions furnished with all machines. A duplicate set of the delicate or wearing parts of any machine should be kept on hand for emergencies.

Milk fresh and warm from the cow is in the best possible condition for a perfect separation. The difference in specific gravity between the



SKIM-MILK OR WHEY PASTEURIZER USING
EXHAUST STEAM.

A. Milk inlet $1\frac{1}{4}$ " pipe. B. Exhaust steam inlet 2" pipe. C. Overflow 2". D. Small valve on exhaust steam pipe to prevent suction of skim-milk back into steam pipe. E. Valve to drain heater. F. Plug which may be removed in order to see if heater is filling with material from skim-milk. G. Heater 6" diameter, 18" long with capscrewed on each end.

fat and other portions of the milk is then greatest, and it is also more fluid, as there is no development of lactic acid, nor chemical changes due to its exposure to the air. At the creamery, it is not met with in this favorable condition; consequently it is necessary to produce artificially as many of the favorable conditions as possible to get the best results. When milk is received at a temperature below 85° it should be heated to from 90 to 100°

A tempering vat should be elevated at a suitable height to allow the milk to flow into the separator; and it should contain enough milk to

employ the separator for at least four minutes. If large bodies of milk are heated to the desired temperature in a vat before separating, acid develops too rapidly and clogging of the separator bowl is likely to follow. Should any accident happen whereby the separator is stopped, the milk would likely develop acid enough to thicken, when it could not be separated.

While it is doubtless true that better butter can be made by pasteurizing the whole milk before separating, still the improvement is not enough to compensate for the extra labor required in cleaning the separator and utensils. There is also the fact that the separator bowl will need to be retinned often if separating pasteurized milk.

The plan followed at the Dairy department at the present time is to heat the milk to about 95° F. before separating. The cream is delivered from the separator into the pasteurizer and heated to 180° to 185° F. The skim-milk is elevated by a pump and just before entering the tank it passes through a heater in which exhaust steam from the engine is used for pasteurizing the skim-milk. The cut will show how this heater may be made. A union should be put in the steam pipe somewhere near the heater, as the heater will need to be taken apart at intervals to be cleaned. This can best be done by burning in the furnace. The amount of milk, and the temperature to which it is heated will determine how often it should be cleaned. Usually it will run from six to eight weeks without requiring to be cleaned.

A great saving in fuel can be made by utilizing the exhaust steam from the engine. At the Dairy department the pipes are so arranged that the exhaust steam can be used for heating the whole milk before separating, heating water, pasteurizing the skim-milk, and heating the building.

Two other labor and trouble saving devices are in use at the dairy which are worthy of special mention. One is a skim-milk weigher which after several years' use we would find it very difficult to get along without. The other is an Ideal hoist for elevating milk at the intake. Having the driveway graded so that no lifting of the can is required is the best plan, but where this cannot be accomplished, the Ideal hoist would seem to be a very satisfactory means of elevating the milk.

PULLEYS AND BELTING. The following rules for finding the size of pulleys and the required length of belting will be found useful in fitting up a creamery or in placing additional machinery.

To find the diameter of a driven pulley, multiply the diameter of the driver by its number of revolutions, and divide the product by the number of revolutions the driven pulley should go. The result will be the diameter of the driven pulley.

Example. Diameter of pulley on the engine, 40 inches; speed of engine, 160 revolutions; speed of main shaft, 200 revolutions: $40 \times 160 \div 200 = 32$, which is the diameter in inches required for the driven pulley.

To find the required size of a driving pulley, multiply the diameter of the driven pulley by the number of revolutions it should make, and divide the product by the revolutions of the driver.

Example. Diameter of the pulley on intermediate is 4 inches, which is required to run 900 revolutions per minute; revolutions of shaft, 200: $4 \times 900 \div 200 = 18$, which is the diameter in inches of the pulley required to drive the intermediate at proper speed.

To find the length of belt for any two pulleys, add the diameter of the two pulleys together, divide this sum by 2, and multiply the quotient by $3\frac{1}{4}$. Add the product to twice the distance between the centres of shafting, and the result will be the required length of belt.

Example. Two pulleys are 8 and 24 inches in diameter, and 8 feet is the distance between the centres of the shafting. $8 + 24 = 32$, $32 \div 2 = 16$, $16 \times 3\frac{1}{4} = 52$ inches = 4 feet 4 inches, and 4 feet 4 inches + 16 (twice the distance between the centres of the shafting) = 20 feet 4 inches, which is the length of belt required.

CREAMERY BUTTER-MAKING.

BY FRED DEAN.

Under present conditions, a very large percentage of cream used for butter-making is separated from the milk on farms, and a certain amount of responsibility is thereby shifted from the butter-maker at the creamery to the creamery patron, in producing a first-class flavored butter. The patron not only produces milk, but also manufactures cream for the creamery. It is evident that no improvement can be made in the quality of creamery butter, until some improvement is made in the care of milk and cream on the farm, and in the condition of the cream when delivered at the creamery. Poor cream is not due wholly to the lack of knowledge on the part of the patron, but more often it is due to habitual carelessness, and to not realizing his responsibility in the production of a better quality of cream and butter.

The value of cream is lessened if it becomes tainted from any cause or source, and the greater the taint the less value it has as a food product. Thus, the best of care should be given it from, and at, the time it is milked until delivered at the creamery. "Cleanliness and cold" are the two essential points in having a pure milk and cream supply. This means clean stables, clean and pure food and water, clean cows, a clean milker, clean utensils for storing the milk and cream in, a pure atmosphere and plenty of cold water and ice.

CARE OF UTENSILS.

If the stables and cows are kept clean, and milking is done in a cleanly manner, it is also necessary to see that all pails are rinsed with cold, or luke warm water as soon as they are emptied. If the milk is allowed to dry on the pails it makes them much more difficult to wash, and bacteria will soon begin their evil work. The practice of a good many patrons is to use the same water for washing the numerous pails and separator devices, pouring it from one dish to another, or washing them all in one vessel, so that the last of the utensils washed are so laden with grease and bacteria, that it would be better if they had not been washed at all. Cloths are used a great deal for washing and wiping, but if patrons would get accustomed to the brush for washing, and scalding water to do the drying, a great improvement would be made in keeping the utensils in better condition. Nothing is more beneficial in keeping utensils sweet and clean than using a good washing powder in the washing water; then steam or scald, and expose for an hour or two in the sun, or near the stove in the winter.

CARE OF SEPARATORS AND CREAM.

Lack of care of the separator and in separating the milk, as well as not properly caring for the cream afterwards, is one of the patron's weaknesses. A good many of the separators are used and cared for much the same as the ordinary farm machinery, which soon leaves them unfit for the use they were intended for. They must be oiled regularly, and turned the full speed, or higher, as indicated on the handle, to do good work.

The cream should not have less than 25 lbs. of fat in every 100 lbs. of cream, and if it does, it is a sure indication of a poor make of separator, a careless operator, or an unintelligent farmer, as no up-to-date farmer of the present day has any excuse for depriving his stock of many pounds of valuable skim-milk, which he does when sending a thin cream. A cream testing between 30 and 35% fat will give the best satisfaction to the patron and buttermaker. After the patron has run the milk through the separator, he should see that the separator is washed at once, and after each skimming. If this is not done, it will be impossible to furnish good wholesome cream to the creamery. The separator should be placed in a dry, clean building, and have a box or half barrel handy for putting the vessel containing the cream in. Fill this box with cold water and ice, and leave the vessel there until the cream hauler calls for the cream. The cream should be given an occasional stir, and fresh or warm cream should not be added to the cooled cream until all is about the same temperature. If every patron would store one ton of ice for every cow that he milks, it would return him more interest on money invested than any other investment he could make. He should do this for his own

interest, and the interests of his neighbor, the buttermaker, and for the reputation of our creamery butter. It is to the advantage of the patrons to see that cream is delivered to the creamery three times per week in hot weather, and that all fat so delivered is accounted for by the buttermaker.

BUILDINGS AND EQUIPMENT.

The finest quality of cream cannot be made into a high grade butter in surroundings which are unsanitary, and with machinery and utensils which are poorly adapted to the work and difficult to keep clean. Some of our creameries are poorly located, poorly built, not well lighted or ventilated, having walls, ceilings and floors not kept any too clean, and with drainage and water supply not so good as they might be. A large majority of them have been adding improvements and making additions—the old box churn and mason worker have been superseded by the latest combined churns; wooden floors have been torn out and replaced by cement. There are two essentials in all creameries, but which are found in few: first, a pasteurizing outfit, which if properly operated will mean a better and more uniform article, a better demand, and a higher price for our butter both on the home and foreign markets. The second requisite is good refrigerators. Some are not properly insulated, but the greatest trouble is getting the makers to keep them supplied with sufficient ice. Butter should not be stored in the majority of them over one week when kept at their best, yet often we find it stored two, three, and four weeks at temperatures from 45° to 60° F. This often spoils an article that was good when first made. Cleanliness of the surroundings and inside of a creamery are essential to thoroughness and a uniform quality of the buttermaker's work.

THE BUTTER-MAKER.

The art of making creamery butter has of late years been followed by too many men who have not had sufficient training and experience before starting to manage a creamery and make the butter. The makers who expect their duties to be inside the four walls of a creamery, in using a thermometer, a pair of scales, ladle, etc., according to a set of fixed rules, will never make a success for themselves or their creamery. Proprietors and co-operative companies owning creameries, will not make a success of their creameries, if they continue to engage incompetent makers because they are cheap, or make butter themselves without the necessary experience, knowledge and training. The best makers are quitting the business because they do not receive satisfactory wages, while the poorer and inefficient maker is receiving too much though working for half the wage offered to a good man. The unsuccessful and closed creameries to-day can be traced to bad management of inexperienced, lazy, careless and indifferent makers, poor haulers paid too much

for what they did and the way they did it, and the acceptance of poor and bad cream. The buttermaker's efficiency is gauged by his ability to make good butter, his tact in handling cream haulers and patrons, and his ability to transact ordinary business, as well as having a knowledge of the technical side of the creamery business in general.

RECEIVING THE CREAM.

No set rule can be given in making a first-class article. If the cream has been received in good condition, and had good care while on the farm, a few given rules will help to guide the maker in some of the most important steps.

The first step is to see that all conductors, pipes, etc., that the cream comes in contact with are free from dirt, dried cream and yellow matter. Where the cream is received in individual cans (which gives the most satisfactory results) the maker should inspect, sample and weigh the cream himself and not leave it to the helper. Where cream is gathered in tanks and large cans, poorer results are obtained, as inspection, sampling and weighing is carried on by men who too often are not competent, and lose many dollars for companies, proprietors, and patrons by their carelessness. Where the hauler does the sampling, etc., it would be money well spent to engage the best man obtainable, irrespective of first cost. It is necessary that the maker should weigh and sample all cream from haulers who do the weighing and sampling at the farm in order to check weights and samples received from them. Cream should not be received that is over-ripe, or tainted from any cause, and makers should insist on having a cream testing between 28 and 30 per cent. fat.

PASTEURIZATION.

Pasteurization is recognized as a useful agent in the production of a better and more healthful product, and will go a long way towards eradicating many of the evils now complained of. It should be the aim of every maker to pasteurize all cream as soon as received. This will check the development of further acid, destroy the more injurious germs, will give an even and uniform quality each day, as well as greatly improve the keeping quality of the butter. The temperature for heating should never be below 170° nor more than 185° F., and should be followed by cooling at once to between 50° and 60° F., by running the cream over a cooler. If the water cooler will not lower the temperature sufficiently, plenty of ice and water should be stored around the vat to hold it at the desired temperature. Give the cream frequent stirrings. If water is scarce, the same water can be used over and over again by letting the waste water run back into a tank under the cooler. Ice is put in this tank and the water forced through the cooler by a rotary pump. The adding of ice directly to the cream is a bad practice. It does not

cool the fat globules uniformly, thins the cream, gives a tallowy flavor to the butter, and imparts an impure flavor from the ice. The ice should be run through a crusher, or be broken very small and placed in the jacket of the cream vat, before the cream arrives. This cools the vat and the cream cools more quickly with the use of less ice. The stirring should be done often in order to give the cream a uniform temperature and acidity. A good cream or skim-milk culture produces a more uniform and better quality of butter.

If sour cream is received in the morning it is a good practice to churn the same day in the late afternoon, providing the cream has been thoroughly cooled for five or six hours. This prevents the development of further acid and requires less ice and labor. Experiments have shown that the sooner the bulk of cream received at the creameries is manufactured into butter the better is the quality of butter.

CHURNING AND WASHING.

The temperature and time of churning depend upon numerous conditions. The churn should not be filled much over half full, and the revolutions per minute of the Success and Simplex churns should be between 18 and 20. A good many of the churns run too slowly, taking a much longer time for churning than is necessary, and also compels churning at too high a temperature. A very high, or very low temperature is not conducive to good results. A temperature between 50° and 56° F., will give best results, and covers nearly all conditions of rich and poor cream, seasons of the year, period of lactation, etc.

The length of time for churning should not be more than 45 minutes, nor less than 30 minutes from the time the churn is started until the buttermilk is ready to be drawn off. If churning is done too quickly, the fat globules will likely be soft and over-churned, there will be an extra loss of fat in the buttermilk, and the butter will have poor body. On the other hand, if too long time be taken, power is wasted, there is an excessive loss of fat in the buttermilk, and the granules are small, round and hard to gather owing to the low temperature or thin cream. The butter should be left in good condition for working—not too hard, nor too soft, and the temperature of the washing water such that it will maintain these conditions. The buttermilk, when ready to be drawn off, should show a perfect separation of the fat globules from the milk serum; a small amount of froth is noticeable on top of the butter and the sight glasses are clean. The granules should be about the size of wheat—uniform and angular in shape, not round. If granules are hard to gather and round, draw off part of the milk serum (buttermilk), add some warm water and then finish churning. The water for washing should be as cold as possible at first to expel the milk serum that may adhere to the granules. Allow the first washing to pass through the churn without revolving, until it comes out clear, then close the tap and add enough water to float the butter. If there is plenty of good water and the cream

is not of good flavor, this water should be let off, and water added again at a higher temperature, say, 2° to 4° higher than the buttermilk, and about the same in amount as there was cream. Revolve the churn with the fast gear, 12 to 20 revolutions, depending on the size of granules when the buttermilk was drawn off, but give sufficient revolutions to increase the size of the granules to that of corn or beans.

SALTING AND WORKING.

As soon as the water has drained, and while the butter is still moist, add a good brand of Butter Salt. (Do not use the common, coarse, cheap kind which adversely affects both grain and flavor.) Apply from 3 to 5 per cent. salt, depending on the market, and whether or not preservatives are used. Do not use over $\frac{1}{4}$ of 1 per cent. preservative, and mix this thoroughly with the salt before applying it to the butter. The salt should be sifted on at the rate of about one-third of the total at one time. Give the churn one-half a revolution after each application. Next adjust the rolls and work at intervals, if the butter is very moist, to allow the escape of the surplus moisture. If the butter is in good condition it may be worked continuously for 12 to 16 revolutions, depending upon the temperature of the butter and that of the surroundings. It should be free from holes and surplus moisture, when cut and pressed with the ladle. The butter trier should be used every few days to see the condition of the previously worked butter. It is claimed by buyers that more objection is made to mottles in butter than to that which has been over-worked. The mottles are mostly caused by the variations and extreme changes in churning and washing temperatures; not expelling all of the milk serum from the butter; too cold and uneven distribution of salt; and insufficient working. The recent advent of several reliable methods for determining the percentage of moisture in butter, makes a new era in creamery butter-making. Their use enables the butter-maker to do more careful and exact work. Butter-fat is a comparatively expensive product, and the butter-maker of the future must regard the composition or per cent. of fat in the butter he sells with just as much concern as the per cent. of fat in the cream he receives. The moisture test now makes such information possible. With this information he can regulate his methods of work so as to prevent any unnecessary loss, and to secure the greatest possible over-run consistent with the best possible quality. The moisture test should be regarded as a necessity in every well regulated creamery, to help control the leaks and losses.

PRINTING AND PACKING.

The neatness, style and kind of a package, is a butter-maker's advertisement to the consumer. These packages, if in one pound prints or blocks, should be oblong, with the corners square, not rounded and flat, and free from holes and finger marks, weighing $16\frac{1}{4}$ ounces to the

pound. There ought also to be a neat design on the wrapper with the name of the creamery stencilled on with a good kind of ink that will not rub off. Fold wrappers neatly and place in a strong 45 or 60 lb. box which has been paraffined and lined with parchment paper. If butter is packed in boxes or kiels, they should be new and clean and the boxes must be paraffined thoroughly on the inside. (Those having spots not paraffined mould very quickly.) The best possible parchment paper obtainable should be used for lining the boxes; preferably two sizes should be used 11.5 inches by 52 inches, and 12.5 inches by 52 inches. These when soaked for 24 hours in a strong brine and one ounce of formalin added will prevent mould. The butter should be packed solidly and be finished neatly on top with a straight edge or fluted roller, allowing $\frac{1}{2}$ to 1 lb. of butter for shrinkage on each box. Weigh each box before and after filling with butter, rather than afterwards only, as carelessness here often gets the maker into trouble. If weights are short, the buyer generally takes off more than he is entitled to, and if giving too much over-weight the proprietor and patrons are both losers.

STORING AND SHIPPING.

The butter as soon as made should be put into the creamery refrigerator, yet often we find it in the make room for several hours in a warm temperature before putting it away. It is also regrettable to find so many creameries without a refrigerator of any kind. If butter is kept one week, and not more than two weeks in the best of the refrigerators, this is quite long enough. If kept for a longer period before being sold it should be shipped to one of the large cold storages, which will store it at a rate of $\frac{1}{8}$ to $\frac{1}{4}$ of a cent per lb., per month, and keep it at a temperature below where any bad flavors can develop or where deterioration can take place. When shipping, care should be given the butter in order to see that it is not roughly and carelessly handled with unclean hands or loaded into unclean wagons or cars; and also that it is not exposed at too high temperatures and to the direct rays of the sun.

CLEANING THE CHURN.

Start churn revolving on the slow gear, rinse out all particles of butter with three or four pails of warm water, let this drain out, and fill churn one-fourth full of boiling water with a small handful of Wyandotte added; wash off the rolls and place these in the churn and wash with the fast gear for one or two minutes. (If left much longer it will wear the holes in the end of the board for the rolls). Allow to drain, take out rolls and rinse out the scum with two or three pails of hot water. Once or twice a week the churn should be steamed and given a wash with lime water. This will keep the churn sweet and clean, and by giving the rolls and inside of the churn a scrub with dry salt occasionally it will prevent the butter adhering.

A GOOD WHITE WASH.

To one-half bushel of unslacked lime add sufficient boiling water to slack it, then cover to keep in the steam. Then prepare, one peck of salt, previously dissolved in warm water, two lbs. glue dissolved in 7 lbs. of water and when dissolved add 6 oz. of bichromate of potash and one-half pound of whiting; now add this to the lime, stir, strain and apply hot, either with brush or spray pump.

BOILERS, ENGINES, STEAM-FITTING.

BY GEO. TRAVIS.

Of all the apparatus necessary for the manufacturing of cheese and butter, the steam boiler seems to be the most essential. From it we get steam power for operating the other machinery, and steam for regulating the temperature of the milk and cream, and for other heating purposes as well; hence the selection, setting and care of the boiler, coupled with the construction of the arch and chimney so as to get the best results from the economic viewpoint, are matters of great importance to cheese and butter manufacturers.

SELECTING A BOILER.

When selecting a boiler, get one of sufficient capacity to furnish all the steam required without forcing the fire under it. A boiler cannot be forced beyond its capacity, without injuring it. There would also be a waste of time and fuel forcing a steam boiler.

SETTING BOILER.

In setting a boiler a good substantial foundation for the arch or furnace should be provided. The arch is really a part of the boiler and unless it is properly built, good results cannot be obtained.

It is best to get a plan for building an arch from some reliable boiler maker. Then have the masonry done by an expert. Provide good fire brick for lining and have them laid with fire clay. Make the side walls of the arch thick with good common brick. This will make it more substantial and retain the heat longer, thus lessening the cost of fuel.

CHIMNEY.

Where coal is being used for fuel the chimney should be built of brick. The area should be at least one-fifth greater than the combined area of all the flues. The height depends largely upon its location—the higher the better.

FIRING THE BOILER.

Boilers newly set should not have fires put under them until the mortar of the brick work has had time to harden naturally. When fire is started, heat very slowly and let the steam go through all the pipes before any pressure is put on them.

CARE OF BOILER.

Before lighting the fire in the morning, care should be taken to see that the boiler has sufficient water in it. The glass gauge in the water column cannot always be depended on at sight, therefore, it is best to open the tap at the bottom of the glass to make sure that the pipes leading to, or from it are not stopped with scale or mud. See that the safety valve is in working order. This is the most important valve in connection with the boiler. Every boiler should have a blow-off pipe at the bottom. In addition to this, it should have a surface blow-off or some "scumming" apparatus. Nearly all foreign matter held in solution in water on first becoming separated by boiling, rises to the top in the form of what is commonly called "scum," in which condition much of it may be removed by the surface blow-off. If not removed, however, the heavier particles will be attracted to each other until they have become sufficiently dense to fall to the bottom, where they will be deposited in the form of scale, covering the whole internal surface of the boiler below the water line, with a more or less perfect non-conductor of heat. Where the water is very hard some good boiler compound may be used with good results. Different waters require different treatments. For ordinary water "sal soda" is all that is necessary.

The blow-off at the bottom should be opened enough each day to let any lime or mud that might have accumulated, escape. If this is not done, there is danger of the pipe being filled with dirt, thus excluding the water from the pipe. Then there is a danger of it becoming hot and bursting, causing a great deal of trouble.

If the pipe from the pump or injector which feeds the water into the boiler be attached so that the water will be fed in through the blow-off pipe, this danger will largely be overcome.

PIPE FITTING.

As there are also more or less steam pipes about the factory that need repairing, it is quite necessary that the maker should know how to do his own pipe fitting.

For ordinary work the tools required are, pipe, tongs, cutter, vise, and stock and dies. With these at hand any pipes or joints that may be leaking can be quickly repaired and will save the expense of sending out for a steam fitter. Steam escaping from bad joints or leaking valves makes a disagreeable noise, and is money evaporating into the air.

ENGINES.

The engine bed or foundation should be solid. If possible have the engine in a room separate from the boiler, as there is always more or less ashes and dust from the furnace and flues. This makes it difficult to keep clean. Any sand or grit lodging on the slides help to wear them out sooner than it otherwise would.

Some of the chief points to be observed are: See that it is kept clean, well oiled, and properly packed to prevent steam from leaking.

Before starting the engine, open the taps of the cylinder to let the water out, turn the fly-wheel over once, then open the throttle valve gradually until the engine gets in full motion.

HAND POWER CREAM SEPARATORS.

By M. ROBERTSON.

It is more than a quarter of a century since the invention of cream separators; that is, since the invention of those which are practicable. However, it is only within the last twelve years that they have come into common use on the Canadian farm.

The first to purchase hand separators were those farmers who patronized creameries or manufactured butter at home. At the present time, however, separators are being introduced into what may be termed cheese factory sections, as farmers in these sections are finding them very useful for that portion of the year in which the factories are closed.

The fact that hand separators have been introduced so rapidly indicates that they must be of economic value to the farmer, as their first cost is comparatively high, the price being from fifty to one hundred and fifty dollars, depending upon the capacity of the machine.

The reasons for such rapid introduction of separators may be summed up as follows: When milk is set in shallow pans or deep cans the force of gravity impels the heavier portion, which is the skim-milk, to the bottom of the pan or can and the cream to the top, but the milk and cream are separated more or less imperfectly. On the other hand, when milk is delivered into the rapidly revolving bowl of a cream separator, which is travelling at the rate of hundreds of feet per second, exerting intense centrifugal force upon the milk, the separation is instantaneous and much more thorough.

Other advantages of the hand separator may be stated as follows:

1. It saves the cost of utensils and the space required for their accommodation.
2. It gives a better and more uniform quality of cream.
3. The richness of the cream can be easily regulated.

4. It saves labor in washing utensils, and in the handling of so much ice for cooling purposes; only enough being needed to cool the cream instead of the whole milk.

5. The skim-milk is in the very best possible condition for feeding purposes.

6. The dairyman is better able to handle his milk and keep more cows with a hand separator, than he was before their introduction, as many were so situated that they could not separate the cream from the milk properly and were out of reach of a creamery or cheesery.

Some of the chief objections to the separator are:—

1. The cost of the machines.
2. The labor involved in turning them.
3. Their complicated construction which makes it difficult to keep them in proper running order.

These objections, however, are more than counterbalanced by the advantages of the separator. Especially is this so, when we consider that the increased product from the extra loss of fat in the gravity skim-milk amounts to from five to ten dollars per cow each year.

In selecting a cream separator the average purchaser is under a great disadvantage, because he is probably buying a separator for the first time and does not know what are the important points to be considered.

At present there are many different makes of separators on the market, but it is impossible to say which is the best, as no one make comprises all the points of merit that the ideal should possess. The best separator may be described as being the one best suited to the special conditions under which it is to be used. The less exhaustive skimmer of two separators might be the more suitable of the two on account of some other advantages it may have over its rival; for example, it might be a more easily turned machine, more easily cleaned, or have some other point of vantage that would make it preferable to one that, while it does more exhaustive work, is hard to clean or turn. A hand separator would be considered as doing good work when running at full capacity it will produce a cream testing from 30 to 40 per cent. fat, and leave not more than .05 per cent. of milk fat in the skim-milk.

The important points in a cream separator are:—

1. Ability to do efficient and exhaustive creaming.
2. Simplicity and durability.
3. Easily turned.
4. Easily cleaned.
5. Low supply tank with reasonable height of handle.
6. Convenience in securing repairs.

In selecting a cream separator the majority of the above points may be fairly judged by the average dairyman, but the loss in the skim-milk and the per cent. of fat in the cream can only be decided by the proper use of the Babcock tester.

With each separator is sent a "Book of Instructions" which contains full directions for setting up and operating the machine. These instructions should be carefully read and followed. A suitable place for keeping the separator should be provided, care being taken that a place is chosen that can be kept clean and free from dust with plenty of fresh air. It is most convenient to have the separating room near the barn, as it saves the labor of carrying the milk too far for separating and the skim-milk back for feeding purposes. It should not be placed in the stable as the air is impure, and the separating of the milk in the stable is bound to pollute the cream, thus injuring the quality of the butter. Also, aside from the matter of cleanliness, and loss in returns from the butter, a separator setting in the barn or stable will become filled with dirt and grit in the bearings, and will wear out much more quickly than if a proper place had been provided.

In setting up the machine, fasten the frame securely to a solid foundation, placing it perfectly level on all sides, as the bowl will soon get out of order if not perfectly level.

Before starting the machine all parts should be thoroughly cleansed and oiled. Special separator oil should be used, as coarse oil will not give satisfaction when applied to such fine bearings. The oil should be thin and clear, giving a clean drop, and free from any crude oils. It is a good practice to flush all bearings with kerosene occasionally as this removes all grit or gummed oil and enables the machine to run more freely.

The speed should be gotten up gradually until the proper number of turns, as indicated upon the handle are reached; this speed should be maintained uniformly throughout the entire run. Enough warm water at a temperature of about 110° F., should be used to fill the bowl, as this moistens the bowl parts and prevents the cream from adhering to them. Milk separates best when fresh and at a temperature of 90° to 100° F. Tests made with different hand separators and at temperatures below 80° F., showed in every case a much greater loss of fat in the skim-milk, than when similar milk was separated at 90° F.; therefore, if for any reason the milk has been allowed to cool below 80° F., it should be reheated to at least 90° F., before separating.

After the milk is all separated the bowl should be flushed with a little warm water (not hot). The power may then be removed and the machine allowed to run down. Do not use a brake, unless one is provided with the machine, as some injury may be done.

After the machine is taken apart all parts should be rinsed with warm water, then washed in water a little warmer, containing some washing compound and afterwards thoroughly scalded with boiling water, then placed out in the sun or in a dry, pure atmosphere. Do not dry with a cloth, simply wash thoroughly with a brush, then scald and the parts will dry themselves. Some owners of separators practice washing them only once each day. This is a filthy habit and cannot be too strongly denounced. Wash the separator thoroughly every time it is used.

Since the coming of the hand separators it has been said that the quality of the cream supplied to our creameries has not been up to the proper standard, and this the writer knows to be true. It is not the fault of the hand separator but of those entrusted with the use of it.

Immediately after the cream has been skimmed from the milk it should be cooled to at least 55° F., by placing it in good, cold water surrounded by a pure atmosphere. If the dairyman has a windmill or a cold spring, a box can be easily arranged where the cream can be kept and the water allowed to flow in near the bottom at one end and the warm water allowed to drain off from the top at the other end. By using shot-gun cans to hold the cream it is soon thoroughly cooled by this method. If no cold water is at hand the dairyman should provide himself with an abundant supply of ice to thoroughly cool his cream.

The question of variation in tests is a vexed one among creamery patrons, and many think that because they do not change the cream screw the test should remain constant. This is an erroneous idea, for while the richness of the cream is adjusted by either a cream or a skim-milk screw, depending upon the make of the machine, still there are many other things which affect the test of the cream, and which may be enumerated as follows:—

1. The per cent. of fat in the milk being skimmed. The richer the milk the higher the cream will test, other conditions being equal.
2. High speed and slow feed will give a high test.
3. Slow speed and full feed will give a thin testing cream.
4. Cold milk will give an incomplete separation and a low testing cream.
5. Allowing the skim-milk outlets to become partially closed with dirt will give a low testing cream.
6. The use of the same amount of flushing water with different amounts of cream will give a variation in the test.

It will be seen by the foregoing statements, that many conditions affect the test; therefore, it is necessary that the operating of a separator be carried on uniformly, and with as little variation in conditions as possible. Every dairyman should own a small Babcock tester, and by its use in testing his cows and the cream he is sending to the creamery, or selling off his farm, he would be in a better position to know exactly what he is doing. It would be a profitable equipment for his dairy.

One other important point in the operation of hand separators is the richness or percentage of fat in the cream skimmed. Too much low testing cream is supplied to our creameries. Patrons sending cream to creameries should endeavor to supply a cream testing between 30 and 40 per cent. fat. The reasons for this are as follows:

1. The high testing cream is less bulky therefore it will take less cooling and work in caring for it.
2. It will leave more valuable skim-milk at home for feeding purposes.

3. It will mean less quantity for the cream haulers, also less vat room at the creamery and a smaller quantity of ice will be needed for cooling purposes.

4. A more exhaustive churning can be obtained from a rich cream than can be got from a thin testing cream, which means less loss in the buttermilk and more money for the patron. Also the high testing cream can be churned at a lower temperature and a better quality of butter be made.

5. The cream with a high percentage of fat will keep sweet much longer than will a low testing cream, providing other conditions are equal, therefore, it is more likely to reach the creamery in proper condition.

Since the introduction of the hand power separator, the patrons have assumed a portion of the butter-maker's duties; that is, the skimming of the cream. Therefore, it is important that they give this part of the work, which they have taken from the maker, their intelligent attention, and aim to supply him with a first-class article, or they will not receive, nor should they expect, first-class returns from the finished product.

FARM BUTTER-MAKING.

BY MISS LAURA ROSE.

While each year sees more milk manufactured at the creameries and cheese factories, butter will ever be made at home on the isolated farm, or where a fancy dairy trade is established.

Where conditions are entirely under one's control it stands to reason that the products can be superior to that made where uncontrolled conditions have to be met; yet it is a lamented fact that much of the dairy butter cannot be classed as first quality. This is probably due to a lack of knowledge in the art of butter-making, and because of the pressure of other duties.

There is always a good market for extra choice food products. If the dairy farmer makes a No. 1 Butter quality and quantity to be always relied upon—he can get a good paying price for it.

Each branch of the farm should be made to pay. There is a lot of labor about the care of cows and the making of butter, and if no profit results, an investigation should immediately be made.

THE COWS.

Many farmers have little or no idea what their cows are doing, or even what to expect in return for good food and proper care. The cow should give after her first milking period 6,000 pounds of milk testing 3.6% milk-fat, or should make from 250 to 300 pounds of butter per

year. The only way to know if the cows are reaching this standard is to weigh and test the milk. Quite accurate results may be obtained by weighing and testing the milk from each cow one day, fortnightly, or monthly. Many farmers have yet to learn that quality, not numbers, is the essential in a dairy herd. Better keep five good cows only, than ten indifferent ones.

THE STABLE.

So many of the bad flavors in milk may be traced to the bad condition of the stable, that it must receive more attention. The building need not be expensive but it must be well lighted. Nothing is such a cheap and effective germicide as sunshine, so let its health giving and germ destroying rays stream into the stable. It must be well ventilated, and be kept clean in order to have the cows healthy and the milk pure.

Nothing adds so much to the appearance of the inside of the stable as giving it an annual coat of whitewash. It can be quickly put on with a spray pump.

FOOD AND WATER.

It is the poorest economy to stint the cows either in the matter of food or water. They need a liberal supply of both, in order to give a large flow of milk. The food should be so balanced as to supply all the constituents for the manufacture of milk.

Many cows drop off in their milk flow during the heat of summer when pastures get poor. A timely provision would prevent this. Nothing is cheaper or easier handled than corn silage, and a small silo for summer use is a wonderful means of tiding over a dry spell and increasing the profits from the herd.

MILKING.

There is no nicer place to milk cows than in a clean, airy stable.

Milk quietly, quickly, cleanly, and thoroughly. Cows do not like unnecessary noise or delays, and show their dislike by diminished quantities of milk. Commence milking the cows at the same hour night and morning, and milk the cows in the same order. Before beginning to milk, wipe the cows' flanks and udders with a damp cloth to prevent loose dust and hair falling into the milk pail. The wide flaring pail is far from desirable. The Freeman pail with its small opening and hooded top prevents much dirt getting into the milk. The first streams of milk should go into a separate dish. They contain many objectionable bacteria. Do not wet the hands with milk—a practice to be recommended is to rub a little vaseline on the hands. This keeps the teats in nice condition and overcomes the desire to wet the hands.

Do not save strippings. Milk the cows out clean, otherwise they will soon go dry.

STRAINING THE MILK.

Remove the milk as soon as possible from the stable and immediately strain it through several thicknesses of cheese cloth. Place the cheese cloth over the bottom of the strainer and secure it with an easy fitting tin hoop. The cloth must be removed and well washed, first in tepid water, then in scalding water, after each time of using.

Remember straining only removes *visible dirt*. Our endeavor, should be to keep the dirt entirely out of the milk. It is the dissolved, unseen dirt that is really harmful.

CREAMING THE MILK.

SHALLOW PANS. This method is the oldest, and is still used when but a few cows are kept or when ice cannot be secured or the supply has become exhausted. Tests of the skim-milk show that when the milk has been properly set and skimmed, the loss of milk-fat is no greater from the shallow pans than from creamers. The milk should be set in clean, bright tins, and should not exceed three inches in depth. It is most necessary that the milk room be clean and free from all odors, as milk so readily absorbs any taint that may be in the atmosphere. The temperature should range between 50 and 60° F. Avoid having the milk close to the wall or in a strong draught, so as not to have a leathery coat form over the cream, due to rapid evaporation. Skim before the milk thickens. Loosen, with a thin bladed knife, the cream from the sides of the pan. Lift the pan to the edge of the cream can, tilt it to allow a little of the skim-milk to wet the edge of the pan, then with the aid of the knife, quickly glide the sheet of cream into the cream can.

DILUTION SYSTEM. Many devices have been put on the market for creaming milk by adding a certain percentage of cold water. We have tried several, and do not recommend any. There is danger of contaminating the cream by using impure water. It robs the cream of its flavor.

The loss of milk fat is usually heavier than when the deep cans are used. The skim-milk is too much diluted for feeding purposes.

CREAMER. If the cream is raised by the deep setting system, the cans should be placed immediately in water the depth of the milk and the milk brought as soon as possible to 45° F. or below, and held at that temperature. *Use plenty of ice.* It is economy to have ice always in the water, and just as necessary to use it in the winter as in summer. A water-tight box or barrel will do as effective work as an expensive cabinet creamer. We prefer a slant-bottom can, with a tap to draw off the milk. Having the slant carries away any sediment and permits all the skim-milk to be drawn off.

Cans without a tap should be skimmed with a funnel-shaped dipper, having a long straight handle and no wire around the rim. With a knife loosen the cream from the sides of the can; wet the dipper in water or milk, then lower it, point first, into the can, allowing the cream to flow evenly into the dipper. Repeat until all the cream is removed. Avoid getting too much skim-milk with the cream.

Milk should always set twenty-four hours before the skim-milk is drawn off, and thirty-six hours in winter is even better. Milk allowed to stand only twelve hours before skimming will give a cream testing from 16 to 18 per cent. fat, while the skim-milk will test as high as from .6 to 1 per cent. Cream from milk allowed to stand twenty-four hours will test from 18 to 22 per cent. fat, and the skim-milk from .25 to .35 per cent., or in other words we have in the latter case a richer cream and less loss in the skim-milk—two desirable conditions in the creaming of milk.

CREAM SEPARATORS. A separate article in this bulletin is devoted to the hand separators; otherwise, much might be said in favor of this method of creaming milk. It certainly is the ideal way of obtaining the cream. A separator, even with only a small herd, pays, for it means less labor, richer cream, less loss of milk-fat and warm skim-milk for the young stock.

CARE AND RIPENING OF CREAM.

Cream which contains from 24 to 26 per cent. fat, or in other words, cream which will make three pounds of butter per gallon is best suited for hand churning.

During the collecting of cream for a churning, the cream can should stand in the coolest place in the cellar in summer, while in the winter it may be kept in a room where the temperature ranges between 50 and 60° F.

The surrounding atmosphere should be clean and sweet. The can must always be covered. Have a tin stirrer which reaches to the bottom of the can and stir thoroughly, from the bottom to the top every time fresh cream is added.

Each time the can is emptied it should be well washed, scalded and put in the sunshine for several hours. In order to be able to do this, it is a good plan to have two cream cans.

When beginning to collect cream for a churning, add to your first skimming a culture or starter which you know has a clean, pleasant, acid taste and smell. This culture may consist of a cup or two of sour cream from your previous churning or the same amount of good flavored sour skim-milk. The reason for adding the culture is that the bacteria which you know produces a fine flavored butter may take possession of the new cream before other germs which might prove objectionable gain control of it.

Another method is to hold the cream sweet until twenty-four hours before churning, then heat it to 65° F. and add one pint of culture to every gallon of cream. In the evening, cool to churning temperature or below, and hold at that temperature over night.

Separator cream should have the foam well stirred in, and by placing in cold water, should be quickly cooled to 60° in winter and from 50 to 55° F. in summer. Stir the cream occasionally while cooling. It is most essential that this thorough and quick cooling be done before adding the cream to the cream can, otherwise separator cream cannot make choice butter.

It is the neglect of this prompt cooling which gives the bad flavor to so much of the dairy separator cream and butter.

Examine the cream, and when it has a smooth, glossy appearance, pours like molasses and has a pleasant acid taste and smell, it is in proper condition to churn. Churning should be done not less than twice a week in summer and three times in two weeks in winter.

To insure a good body in the butter have the cream lowered to churning temperature or below, several hours previous to churning. It does no injury to raise the temperature to that desired, but when the temperature of the cream is lowered just before churning, the fat globules have not had time to harden, and the result will be a soft, weak-textured butter.

To prevent loss of butter fat in the buttermilk, sweet cream should not be added during the last twelve hours before churning.

Perfectly sweet cream will churn in the same time as ripened cream and makes a mild creamy-flavored butter which is gaining in favor in the best markets. If the temperature of sweet cream is kept low there is no excessive loss of butter in the buttermilk.

I think the time is not far distant when little cream will be ripened for butter-making purposes. The sole care of the butter-maker will be to have the cream as clean and sweet as possible.

Complaints are sometimes made about a bitter flavor in cream. When held sweet for sometime at a very low temperature this bitterness frequently develops. To overcome this difficulty, either pasteurize or get the cream started to sour.

PASTEURIZATION.

For farm butter-making we do not consider pasteurizing the cream necessary, but if bad flavors are found in the sweet cream it will, to a great extent, destroy them. If cream obtained from cows a long time in milk proves difficult to churn, pasteurizing it will assist greatly in getting the butter to come.

To pasteurize cream, place the can holding the cream in a dish of hot water on the stove, and bring the cream to 160° F., and keep at that temperature for twenty minutes; then quickly cool to 60° F. or below. It is always necessary to add a culture to pasteurized cream if you wish to ripen it.

THE CARE OF THE CHURN.

Before using, the churn should be scalded with boiling water and afterward rinsed with cold water. It is better and quicker to pour the water out than let it run through the bung-hole. Floating dust will not then cling to the sides of the churn. After using, the churn should be rinsed down with hot water to remove any particles of butter, then thoroughly scald with hot water to which has been added a little good washing soda compound, after which it should be well rinsed with boiling water. Wipe the outside, but do not touch the inside with a cloth. Never allow buttermilk or wash water to remain in the churn when not in use. Leave the plug out and the lid ajar, and keep in a cool place to prevent warping.

The worker, ladles, and butter-print may be prepared just before using. With a fibre brush, a dipper of water, and a little salt, give them a good scouring and cool well with cold water. After using, remove any butter with hot water, again scour with salt, rinse with boiling water and allow them to dry.

CHURNING.

Always strain the cream into the churn through a dipper with a perforated tin bottom. In winter add just sufficient butter color of a reliable brand to give a nice yellow tint. Do not depend on pouring it in, but count the drops for a small churning, allowing 3 or 4 drops to the pound of butter.

No definite temperature for churning can be given, but the necessity for the constant use of a thermometer must be emphasized.

Many conditions influence the temperature of the cream for churning. These are often not given due consideration and consequently cause trouble. It must be remembered that the poorer the cream in fat; the fuller the churn; the drier the food of the cows; the longer the cows have been in milk; the colder the room in which the churning is done—all these are conditions which demand higher churning temperature. Aim to make conditions favorable for a low churning temperature, as it insures a better butter and a more exhaustive churning. Long churning is sometimes caused by slow speed of the churn—so long as the cream drops it does not matter how fast the churn revolves—the extra concussion hastens the process of churning.

Start with the churn about one-third full, which means not more than five gallons in a No. 3 churn, and regulate the churning temperature so as to have butter within from 20 to 30 minutes. That proper temperature can only be ascertained by past experience with similar cream.

I would suggest a range of temperatures for summer from 54 to 58° F. and in winter from 58 to 64° F.

Cream that contains too much skim-milk and is too cold will foam. Never add hot water to the cream. It must be taken from the churn and heated by placing the can in a pan of hot water and stirring until the desired temperature is reached.

Poor cream often breaks, but will not gather. Try churning slowly. If this does not overcome the difficulty the only remedy is to add a little water a few degrees warmer than the cream. Revolve the churn a few times, let stand a minute or two, then draw off part of the buttermilk to lessen the liquid and churn slowly.

Very rich cream is likely to paste or thicken in the churn, so that concussion ceases. Add enough water at the same temperature as the cream to dilute it so that it will drop.

When the churning is about completed, add a couple of quarts of water several degrees lower in temperature than the cream was. In the summer it may be quite cold. This floats the butter and allows the buttermilk to run off more freely. When the butter is the size of wheat grains it is sufficiently gathered. Look frequently at the inside of the churn lid, and when but few small specks are seen on it, the churning is usually finished. Watch the buttermilk as it runs through the strainer dipper, and if any butter comes with the first streams, a little more churning is necessary.

WASHING THE BUTTER.

When the buttermilk is drawn, rinse the butter with a little water to further remove the buttermilk. Temper the water in winter, having it from 50° to 58° F. according to the condition of the butter and the temperature of the room. In hot weather the wash water may be as cold as possible. Have as much or more water as there was cream. Strain it into the churn through cheese cloth. Revolve the churn rapidly about a dozen times, and wash but once. We recommend washing butter twice if it has come very soft or has an objectionable flavor, or is going to be packed for winter use.

SALTING THE BUTTER.

Salt according to the demand of the market. If the butter is for immediate use and is salted on the worker $\frac{3}{4}$ ounce per pound of butter is usually sufficient. If salting in the churn use an ounce, as not so much is incorporated in the butter. We strongly recommend salting in the churn, as by so doing butter free from streaks can be had with the least possible amount of working, but the churn must be without dashers, and the butter in firm granular form. The only difficulty in this method is gauging the amount of salt. Estimate the weight of butter from the last churning, then weigh the salt. Have the butter evenly spread over the bottom of the churn, sift on part of the salt, tilt the churn forward to cause butter to lap over, sift on more salt, then tilt the churn back-

ward and put on the remainder of the salt. Put on the lid and revolve the churn very slowly until the butter forms in several lumps. It may be taken out and immediately worked, but if possible it is much better to allow it to stand either in the churn, or in a firkin, if the churn is in too warm a place, for one or two hours, and then give one working.

If salting on the worker, take the butter from the churn, weigh it, and allow $\frac{3}{4}$ ounce of salt per pound of butter. Spread the butter over the worker, sift the salt on evenly, fold the salt under and begin working.

WORKING THE BUTTER.

For the farm dairy there is nothing nicer than the V-shaped lever butter-worker. It is not expensive and is a great saver of time and strength, besides preserving the grain of the butter.

Work by means of pressure only; avoid a sliding motion, as it makes a greasy, salvy butter. Work sufficiently to expel the moisture and thoroughly distribute the salt. Any portion of the butter not reached by the salt will be light in color.

If the butter is very soft or very hard, work but slightly, allow it to stand, and when at the proper firmness give it a second working.

PRINTING THE BUTTER.

The brick-shaped pound print is the most popular form in which to market butter. Finish the butter smoothly and press the print down into the butter until the mould is well filled. Cut with a ladle the surplus butter from the bottom. Wrap the print neatly in good parchment paper, which has been previously wet in clear, cold water. It is a good plan to have the paper stamped with the name of the farm or butter-maker. It is often the means of securing a choice trade. Be sure the print weighs a full pound or slightly over. The butter when wrapped in the wet wrapper should weigh full $16\frac{1}{4}$ ounces.

Keep the butter in a cool clean place and get it to the consumer as soon as possible.

PACKED BUTTER.

When the butter is to be kept for winter use we advocate pasteurizing the cream and seeing that in every respect it is of No. 1 quality. Wash twice and salt heavier. Either allow it to stand in the churn for several hours after salting, or give it two workings. Pack in well glazed, thoroughly-scalded crocks; finish off to within $\frac{1}{2}$ inch of the top. Cover with parchment paper and with a layer of moistened salt. Tie down with paper, and keep in a dark, cool place. If the salt on top dries, add water to it. It is better to keep the butter frozen if possible.

THE CARE OF MILK PAILS, PANS, CANS, ETC.

Clean all dairy utensils by first rinsing in tepid water, then clean inside and out with a brush and hot water in which a cleansing material such as washing soda is dissolved. Lastly rinse with plenty of boiling water and leave inverted in pure air and sunshine, when available, until wanted for use.

APPLIED PROVERBS.

Praise the day at eventide, and the cow at the end of the year, if she then deserves it.

Children are the riches of the poor; but if you get them interested in the dairy they will help lift the mortgage from the farm.

The shoe knows whether the stocking has holes; the farmer *should know* where the leaks are that rob him of the profits from his dairy, and should set about mending them.

Cleanliness is next to godliness; this applies as much to the *cow stable* as to the *front parlor*.

It is hard for an empty sack to stand straight; but still harder for a lazy man to succeed in the dairy business.

We'll take the good will for the deed. Did you ever hear the cows say that when you neglected to properly feed and water them?

Penny wise and pound foolish is the woman who still uses old-fashioned, out-of-date dairy utensils.

'Tis good in every case you know
To have two strings unto your bow;
Some clucking hens and a brooding sow
Increase the profits from the dairy cow.

FARM CHEESE-MAKING.

BY MISS LAURA ROSE.

Most of our country people are English enough to like home grown and home made food products. This is mainly why the making of small farm cheese appeals to them. If made at the time of year when milk is cheap one can produce an extra nice quality of cheese at a very reasonable cost.

Cheese does not hold its proper place in our dietary. It should be more largely used on our tables, and should often take the place of meat at a meal. A well-made, well-cured cheese is highly nutritious, not hard to digest, and if made in the home would be more freely used.

In manufacturing cheese on the farm we make the process as simple as possible.

From the time of starting until the cheese is put to press is between four and five hours.

The milk must be sweet and pure. If the fresh morning's milk is mixed with the previous day's milk it is usually in about the right condition for making cheese in regard to the acidity. With the acidimeter it should show .18 to .19 per cent. acid or by the rennet test 20 to 24 seconds.

A large tin or new tub, in fact any clean vessel which will hold milk and not injure it, will answer as a cheese vat.

Heat the milk to 86° F. by setting it on the stove and stirring or by placing a clean can of hot water in it, and keep it as nearly at that temperature as possible. If the cheese is to be colored, use one small teaspoonful of cheese color to 100 lbs. of milk (10 gallons). Add the color to a pint of the milk and stir well into the milk in the vat.

For every 25 lbs. of milk use one teaspoonful of rennet. Try to get the rennet at some cheese factory; junket or rennet tablets, such as druggists sell, are often not satisfactory. Dilute the rennet in a cup or more of cold water and pour it in a stream up and down the milk, stirring well all the time, and continue stirring two or three minutes. Cover the vat to keep the milk warm. Try the milk occasionally to see when it has sufficiently coagulated, by inserting the index finger into the curd and with the thumb making a dent or slight cut in the curd just at the base of the finger, then slowly moving the finger forward; if the curd breaks clean like a firm but tender custard it is ready to cut. The time from setting or adding the rennet to cutting is usually about twenty minutes. The older or riper the milk the more quickly the rennet will act upon it. Over-ripe milk will give a dry, acidy cheese.

If one expected to make much cheese I would advise getting a set of curd knives. While more tedious, a long bladed carving knife, or thin bladed sword answers the purpose. First cut lengthwise into strips, one-third of an inch wide, then crosswise the same, as well as one can horizontally. Begin stirring gently and continue the cutting if the carving knife is used till the curd is of uniform size. At the same time heat may be slowly applied. The vat may be set in a vessel holding warm water, or a clean can filled with hot water may be put into the vat. One-half hour should be taken to get the curd heated to 98 degrees. After it is brought to that temperature it is not necessary to stir continuously, but it must be frequently stirred to prevent the curd from matting, and the temperature must be maintained. The curd is usually ready to dip three and one-half hours from the time the rennet is added to the milk. The right condition for the curd to be in at this stage is ascertained by feeling the curd. If it is rather firm, has a shiny appearance, and falls apart when pressed in the hand, it is ready to have the whey drawn.

By the acidimeter it should show from .19 to .2 per cent. of acid, or when a little of the curd is squeezed well in the hand and pressed against a hot iron (a stove poker answers the purpose) and when gently withdrawn leaves fine hair-like threads one-quarter of an inch long on the iron, it is a sign the whey should be removed.

If the vat is without a tap, dip the curd and whey into a strainer dipper or colander and put the curd in a large cheese cloth on a lever butter worker, if one is in the house. The curd must be well stirred for ten or fifteen minutes to allow the whey to escape; then it may be salted at the rate of one ounce to every 25 lbs. of milk. Sprinkle the salt over the curd; stir well, and allow it to stand a little while before putting it in the hoops. One cannot get along without a cheese hoop. It may be of wood or tin, but must be round, straight, strong and the ends clean cut without any rim to them. A nice size is 7 inches in diameter by 14 inches high; this will press a cheese weighing from 6 to 10 lbs.

The circle or follower of wood placed in the hoop on top of the curd must fit well or the cheese will have shoulders.

A bandage made of cheese cloth should be placed inside the hoop, and the curd put into it and a square of cotton wet in hot water, placed on the top before the wooden follower is put on. The temperature of the curd when put to press should be from 80° to 84° F.

Many contrivances may be used to apply the pressure—a cider press answers, or a fulcrum and lever press is easily constructed. Too much weight must not be put on at first, and the pressure should be increased gradually.

The next morning the cheese should be taken from the hoops, dampened with hot water on the outside, the bandages straightened and trimmed and the cloth allowed to extend half an inch over the ends. Cut a circle of cheese cloth, the size of the top, place carefully on the cheese, cover with a square of wet cotton, place the hoop on top and force the cheese into it. Finish off the other end in the same way. Put again to press till the next day. Take from the hoop and place in a cool cellar, turning it upside down every day for a month and then occasionally. Do not worry, if it moulds; it will be on the outside only, and should be well washed off before the cheese is cut. At the end of two months it should be ready for eating, but is better if kept for five or six months.

If the milk be sweet and good and the necessary care taken in the manufacture, this method produces a rich, meaty cheese much liked by every one.

SOFT CHEESE-MAKING.

BY FRANK G. RICE.

In dealing with the subject of soft cheese-making only a general idea of the process can be given, as one has to alter one's process according to circumstances, such as, variety of cheese to be made, and the age of the milk from which the cheese is to be manufactured.

The making of soft cheese is, practically speaking, new to this country, so that the taste for these dainty little cheese needs cultivating.

As these cheese will not keep for any length of time, being usually eaten in the fresh state, one must have a ready market for them.

The main object in soft cheese-making is to retain in the cheese a high percentage of moisture. It is this high percentage of moisture together with the fat, which produce the soft texture; hence the name, soft cheese.

The process of manufacture is as follows: Fresh whole milk is brought to a temperature of 82° F. to 84° F. (As it is necessary to have perfectly sweet milk, milk straight from the cow stable, which has not lost its animal heat, is preferable.)

Sufficient rennet is added to this milk to bring about a soft and tender coagulation in about one hour. When the curd is sufficiently firm it is dipped with a culture ladle in small slices into moulds of various shapes according to the variety of cheese to be made, standing on straw mats to facilitate draining.

At the first dipping only sufficient curd is taken to cover the bottom of the moulds. At intervals of 15 minutes, more curd is put into the moulds until they are full and no more curd remains to be dipped.

The cheese are left to drain at a temperature of from 62° F. to 70° F., according to the time of year—the lower temperature for the summer. When the cheese are sufficiently firm to handle, the moulds may be removed and the cheese salted. Salting is done by carefully rubbing the salt all over the outside of the cheese.

These cheese need very careful handling, as rough handling causes loss of fat and curd, resulting in an inferior cheese being produced.

Now the cheese are ready for market, and will keep for about one week at a temperature of about 55° F. It is essential that the temperature of the making room should be constant and the atmosphere not too dry.

Among the varieties of cheese made at the Dairy School are the following: Double Cream, Gervais, Cambridge, Camembert, Coulommier and Wensleydale.

The first two are made from mixtures of cream and new milk; the other four from fresh whole milk. All these cheese made at the Dairy School have met with a ready sale.

As an example of soft cheese-making we shall discuss in detail the manufacture of Coulommier Cheese. This is a cheese which is ready to eat sooner than most, and usually meets with a ready sale.

COULOMMIER CHEESE. 10 lbs. of milk will produce two cheese weighing about 1 lb. each. Take 10 lbs. (1 gallon) of fresh sweet milk and heat to a temperature of 84° F. Add sufficient rennet to bring about a tender, though firm coagulation in one hour. The quantity is usually one cubic centimeter (1 c.c.) per 10 lbs. milk, but it depends on the strength of the rennet used. Stir in the rennet for about five minutes. Five minutes later stir the surface to keep the cream from rising before coagulation has taken place, as any cream on the surface at the time of coagulation will be lost in the whey. When the coagulum is sufficiently

firm, place the moulds on a well scalded board and a clean straw mat. The mat is placed between the moulds and board to facilitate draining. Dip sufficient curd, with a culture ladle, into the moulds to cover the bottom, care being taken not to break the curd by letting it drop into the moulds, as any broken curd results in a loss of cheese.

At intervals of 15 minutes, more curd may be dipped into the moulds. All the curd is dipped, usually, in six to seven dippings.

When the cheese have shrunk half way down the moulds, the upper rim may be removed and the cheese turned by means of placing another straw mat and board on top and inverting the whole. Remove the straw mat and board which were at the bottom, but are now on the top, care being taken not to break the top of the cheese. This takes place the following day.

When the cheese have shrunk a little more, the upper side may be salted by sprinkling on a little fine dry salt. When the cheese are firm enough to handle, the moulds may be removed and the cheese turned with the hand onto a clean mat, at the same time salting the other side and rubbing a little round the edges.

The cheese are now ready for consumption and will keep good for six or seven days at a temperature of 50° to 55° F. The size of the cheese when finished is 5 inches in diameter and $1\frac{1}{2}$ to 2 inches deep, weighing 1 lb. or a little more.

The moulds are in two pieces—the top fitting into the bottom. The circular top is 5 inches in diameter and $2\frac{3}{4}$ inches deep, and the bottom is 5 inches in diameter and 3 inches deep. The boards should be 14 inches by 8 inches and $\frac{1}{2}$ inch thick. The straw mats are 13 inches by 9 inches.

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THE BIRDS OF ONTARIO

IN

Relation to Agriculture

(Fourth Edition)

BY

Charles W. Nash, Toronto

(PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE, TORONTO)



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The Birds of Ontario in Relation to Agriculture

By CHARLES W. NASH

Among the most injurious pests of the farmer and fruit grower, are the small animals commonly known as rats and mice; individually they are insignificant; but where permitted to increase, their productiveness soon renders them formidable.

It is very difficult to make anything like a correct estimate of the average damage inflicted upon the country by these creatures, but every farmer knows by sad experience that he continually suffers from their work. |

The enormous amount of grain they destroy and the young trees girdled and killed by them, are visible to everyone, but the perpetrators of the mischief, owing to their nocturnal habits and secretive lives are comparatively seldom seen. Their enormous increase of late years and consequent capacity for serious mischief, is, of course, owing to the fact, that man has seriously interfered with the balance of nature and has thoughtlessly, perhaps, destroyed the principal natural enemies of these creatures.

Man himself is almost powerless to stop their ravages to any great extent. The constant exercise of his ingenuity in trapping and so forth results in very little and occupies his time to no purpose. The natural enemies of these animals are gifted with special faculties for their destruction and so are able to cope with them. Chief among the enemies of this class of farm pests are the Hawks, Owls, Shrikes and Crows. These birds are wonderfully provided by nature with the means to fulfil their part in maintaining the correct balance between the small rodents and plant life and if not destroyed by man would, so keep down the numbers of these small four-footed thieves, that their plundering would be scarcely noticeable.

Unfortunately all the birds of prey are considered by uninformed people to be chiefly poultry killers and therefore enemies, while the truth is that with but few exceptions, as is shown further on, our common species are beneficial; and should be protected.

The incessant destruction of these birds if permitted to continue, will sooner or later result in such an increase of mice, that they will become a devastating plague, as they have several times in Great Britain and notably in Scotland in the years 1888 to 1892 when parts of Roxburghshire, Selkirk, Peebles, Lanark and Dumfries were over-run by field mice and every growing thing practically destroyed. In order to ascertain the cause of this outbreak and if possible find a remedy,

a committee was appointed by the British Board of Agriculture of which the Earl of Minto, our late Governor-General, was, I think, chairman.

Evidence was given before this Committee by about eighty farmers and shepherds and by several gamekeepers; their testimony proving conclusively (1) That the effect of the outbreak was to practically destroy all crops. (2) That the cause of the increase in number of the mice was the destruction of hawks, owls, weasels, and other natural enemies of the mice. (3) That remedies are expensive and difficult of application. Poison on small enclosed areas was efficacious, but its application over farms, even if practicable would be attended with much risk to other forms of life. Traps while successful in destroying many are troublesome to make and expensive.

Cats though tried on a large scale were of no service whatever. Large numbers were killed by men and terrier dogs; systematic work by a man and several dogs giving better results than any other method employed, one man with his dogs having destroyed fifteen thousand in a month.

The result of this investigation was that the persecution of Hawks and Owls ceased and these birds soon gathered in the district affected, in sufficient numbers to clear off the mice.

No phenomenon in connection with the plague of field mice in Scotland was more marked than the arrival and continued residence in the affected districts of large numbers of the Short-eared Owl. This bird which is distributed over every part of the world and used to be quite abundant in Canada, is a regular winter migrant to the British Islands, arriving there in autumn and departing in the spring. Under ordinary circumstances it very rarely nested in Great Britain, but in consequence of the vast multiplication of their chief food, the meadow mice, these Owls not only flocked to the spot in great numbers, but as they were undisturbed and in fact protected, they remained and bred freely in the infested district, laying too, a larger number of eggs for each brood than is usual with them and they also raised more than one brood in the season. The Owls destroyed so many of the mice in feeding their young, that on some of the farms the shepherds stated that the ground was covered with the "castings" of the Owls, composed entirely of the fur and bones of the mice.

The committee finally reported: "It would be difficult to condemn too severely the foolish action of those who allow or encourage the destruction of Hawks and Owls. It is with much satisfaction that your committee record that many farmers and land owners seem to have become convinced in late years that Hawks and Owls are not only harmless but most beneficial to agriculturists and have issued orders for the preservation of these birds."

Our position in Ontario may at any time, if we are not careful resemble that of the Scotch farmers in 1892. It would be well therefore for our people to exert their best influence for the protection of our beneficial Hawks and Owls at once, in order to avert what may develop into a serious calamity.



Sharp-shinned Hawk.



Goshawk.

The birds of prey may be roughly divided into two classes, the Hawks and the Owls. Of the Eagles little need be said; they are now so rarely found in the cultivated districts that their influence for good or ill is practically nothing.

HAWKS.

Of the hawks there are eleven species, occurring regularly in this Province in greater or less abundance every season. These are the Marsh Hawk, Sharp-shinned Hawk, Cooper's Hawk, Goshawk, Red-tailed Hawk, Red-shouldered Hawk, Broad-winged Hawk, Rough-legged Hawk, Duck Hawk, Pigeon Hawk and Sparrow Hawk; there are two or three others, but they are only occasional visitors. Of these eleven, the Sharp-shinned Hawk, Cooper's Hawk, Goshawk, Duck Hawk and Pigeon Hawk are the species which occasionally make raids upon the poultry yards, and which at all times seem to prefer feathered game to either fur or insects; they should, therefore, be shot whenever the opportunity is given. The Sharp-shinned Hawk and Cooper's Hawk are the two species which most frequently attack poultry. They are both small hawks, but make up for their lack of size by boldness and dexterity. It is but seldom they attack a full-grown fowl, but if they once find an accessible lot of chickens they will continue to visit the flock until they have taken them all, or are killed in the attempt to do so. The mischief done by these two species has been the principal cause of the prejudice existing among farmer's against all the hawk tribe, and is usually given as an excuse for the slaughter of the valuable species whose constant work inures to man's benefit. The food of the Duck Hawk and Pigeon Hawk consists chiefly of wild birds. They rarely visit the farms, their usual resort being the marshes and shores of lakes frequented by water fowl. The Pigeon Hawk is not so named because it has any preference for pigeons, either wild or domestic, but because it slightly resembles a pigeon in shape both when on the wing and when at rest.

The Goshawk fortunately does not visit the cultivated portion of Ontario in any numbers regularly; it is a winter visitor usually; and rather an expensive one to entertain when it does come. The winter of 1896-7 was one of the seasons in which it was particularly abundant through southern Ontario, and poultry owners suffered greatly from its destructive powers in consequence. This Hawk is a large, powerful bird, quite capable of killing and carrying off a full grown hen. Owing to its boldness and strength it is capable of doing a great deal of damage, and should consequently be killed whenever seen. As previously stated, this hawk generally occurs in winter, and therefore it is not likely to be mistaken for any of the hawks whose food habits are beneficial. As a general rule, if a hawk is seen about the farm-yard during the winter it is safe to assume that it is there for no good purpose, and the gun should be brought into requisition at once, as all our beneficial hawks migrate southward when cold weather sets in.

From the above species, all of which are undoubtedly injurious to the interests of the agriculturist by reason of the destruction they work in the poultry yard, and amongst our insectivorous wild birds, we turn to the remaining six species of hawks frequenting this Province, every one of which spends the greater part of its time and devotes its energies to the destruction of animals and insects which are known to be amongst the greatest pests the farmer has to contend with; these are the Marsh Hawk, Red-tailed Hawk, Red-shouldered Hawk, Broad-winged Hawk, Rough-legged Hawk and Sparrow Hawk.

Nearly everyone knows the Marsh Hawk and has seen it gracefully skimming over the low meadows, occasionally hanging poised over one spot for a second or two, and then dropping down into the long grass; this drop generally means the death of a meadow mouse, sometimes, but more rarely, a frog; of these two creatures its food principally consists, and the number of meadow mice destroyed by each of these birds in a season must be something enormous. As many as eight have been found in the stomach of one of these hawks, and four or five quite frequently. The hawk's digestion is very rapid, and their hunting and feeding is continued with but few intermissions from daylight until dark.

How many mice each bird would take on the average each day would be difficult to state exactly, but it is safe to assume that at least six would be required. Now multiply that by the vast army of hawks that resort to this Province and the total number of mice destroyed would be amazing; and then against this good work constantly going on there is no damage to be set off. Not one instance, in forty years observation of this bird's habits, has ever come to the writer's knowledge of their having attacked a single domestic fowl. It does sometimes make a meal off a dead duck or other bird it may find in the marshes, but it is doubtful if it ever kills for itself a bird of any kind, at any rate in this Province. Every farmer and every sportsman in the land should do his utmost for the protection of this hawk. Unfortunately they are constantly destroyed by persons who are ignorant of the good they do, and thousands are killed every autumn by mischievous people who must shoot at everything they see that has life in it. If people who wantonly shoot hawks would sometimes look at the stomach contents of the birds they kill they would soon be convinced of the wrong they were doing and would perhaps exercise sufficient common sense to refrain from continuing the evil practice.

For the sake of brevity the Red-tailed Hawk, Red-shouldered Hawk, and Broad-winged Hawk may be considered together. These three common species are usually known as "Hen Hawks." Why, however, it would be difficult to say. They are all fairly large, slow, heavy flying birds, whose food consists principally of mice, squirrels, toads, frogs and snakes; very rarely do they ever take a bird of any kind. In fact it would be extremely difficult for them to do so, unless the bird was very young, or injured seriously. They will, when pressed by



Marsh Hawk.



Rough-legged Hawk.

hunger, feed on carrion, but the staple article of diet with them is meadow mice and squirrels, varied, as before stated, by toads, frogs and snakes, besides grasshoppers and other insects.

I have especially omitted from this group, to which it really belongs, the Rough-legged Hawk. This is done purposely, because the great value of the species to the farmer should be particularly pointed out, the bird having been most unjustly persecuted. It is the largest of the Canadian hawks, and one that deserves the greatest consideration and protection from every man having an interest in agriculture. It can be safely said that this so-called "Hen-Hawk" has never killed a head of poultry at any time, nor do they ever kill birds of any sort. During the fall of 1895 these hawks were very abundant in southern Ontario and large numbers were killed. I obtained all the bodies I could for the purpose of investigating the contents of their stomachs, and I spent much time in watching their habits whilst feeding. All day long, every day from the first of October of that year to November 28th, the birds were constantly passing slowly through southern Ontario, feeding as they went, and not one fowl was taken or attacked by them anywhere, so far as I could learn, and I made enquiries from poultry keepers wherever I could. In all, 32 specimens were examined by me, and the result corroborated my previous experience. In one stomach I found a frog, in another the flesh of a muskrat — taken from a pile of bodies of these creatures which had been thrown together in Ashbridge's Marsh. Another stomach was filled with large grasshoppers, and the rest contained mice, and nothing but mice, or traces of them, ranging in quantity from a little fur and a few bones to seven whole ones. From this it can be judged whether or not the Rough-legged Hawk is the friend of the farmer.

The attention of the Department of Agriculture at Washington was some time ago called to the fact that mice and other destructive rodents were largely increasing throughout the United States, and it was suggested that the constant destruction of the hawks and owls was the reason for it. In consequence of this the Department placed the matter in the hands of Dr. Merriam and Dr. Fisher, two of the leading ornithologists of America, with instructions to prepare a report on the subject. This they have done, and the result of their investigations, which I shall give at the end of this chapter, shows conclusively that all the hawks which I have referred to as being beneficial to agriculture are of the greatest possible value in ridding us of enormous numbers of destructive animals, and they are practically innocent of the commonly urged charge against them of poultry-killing.

There is only one more species of hawk to be considered, and that is the beautiful little Sparrow Hawk probably the commonest of all our hawks, and which may be distinguished from any of the others by its smaller size and red back. It may be constantly seen hovering over fields in Ontario, all through the summer, for it breeds with us, raising its young in a convenient hole in a tree, frequently choosing one that has been deserted by one of the large woodpeckers. The very small size

of this bird precludes the idea that it can take a full grown fowl, or even a pigeon, and I have never known in my own experience that it has even taken a young chicken. Its principal food consists of mice and grasshoppers, of both of which it consumes, immense quantities, but it does occasionally take wild birds, more particularly those which frequent the open fields and skulk in the grass or run about the stubble. The birds taken by this species are, however, so few compared to the number of mice which it destroys, and so much good is done in reducing the swarms of grasshoppers which infest our fields, that we may well forgive its slight trespasses, the balance of good over evil being so great that this bird deserves our protection. The following shows the result of the investigation made by Dr. Fisher at the request of the Department of Agriculture of the United States:

Red-tailed Hawk. 562 stomachs examined: 54 contained poultry or game birds; 51, other birds; 409, mice and other animals; 37, reptiles, etc.; 47, insects; 9, crawfish, etc.; 13, offal; and 89 were empty.

Red-shouldered Hawk. 220 stomachs were examined: 3 contained poultry; 12, other birds; 142, mice and other mammals; 59, reptiles, etc.; 109, insects; 7, crawfish; 2, offal; 3, fish; and 14 were empty.

Broad-winged Hawk. 65 stomachs were examined: 2 contained small birds; 28, mice and other mammals; 24, reptiles, etc.; 32, insects, etc.; 4, crawfish; and 7 were empty.

Rough-legged Hawk. 49 stomachs examined: 45 contained mice and other mammals; 1, lizards; 1, insects; and 4 were empty.

Sparrow Hawk. 320 stomachs examined: 1 contained a quail; 53, other birds; 101, mice and other mammals; 11, reptiles, etc.; 244, insects, etc.; and two were empty.

Marsh Hawk. 124 stomachs were examined: 7 contained poultry or game birds; 34, other birds; 79, mice and other mammals; 9, reptiles, etc.; 14, insects; and 8 were empty.

Thus it can be seen that of the 49 stomachs of the Rough-legged Hawk examined by Dr. Fisher, and the 32 examined by me, in 1895, not one contained a trace of any domestic fowl and nearly everyone contained mice. Yet many people persist in calling this bird the "Big Hen Hawk" and in treating it as an enemy, when both by law and public opinion it should be protected by every possible means. The statement as to all the other species that I have referred to as beneficial is equally corroborated by my own experience, and shows how well entitled these birds are to consideration at our hands instead of the persecution they usually meet.



Sparrow Hawk.

DESCRIPTION.

INJURIOUS HAWKS.

DUCK HAWK.

Adult. Upper parts dark bluish slate color; primaries barred with ochraceous; tail and upper coverts barred with blackish and ashy grey and tipped with white; under parts creamy buff barred and spotted with black except on throat and breast. A black patch on each cheek, wings stiff, long, thin and pointed. Bill bluish, notched; the cere yellow. Talons long and black.

Immature. Upper parts fuscous, more or less margined with pale rufous; region below the eye black; ear coverts buffy; under parts cream-buff streaked and spotted with black. Male L 16.00; W 12.25; T 6.50 Female L 19.00 W 14.00 T 7.50.

Nest, on rocky cliffs. Eggs, three or four varying from creamy white heavily marked with cinnamon brown to pale reddish brown more or less marked with shades of same color.

PIGEON HAWK.

Adult. Upper parts slaty blue, a broken rusty or buff collar on the neck, primaries barred with white; under parts buffy or almost fawn with long blackish marks except on the throat which is almost white. Tail with three or four greyish white bars and white tip.

Immature. Upper parts brownish fuscous, a broken buffy collar on nape, primaries barred with ochraceous; tail with three or four incomplete buffy bars and a whitish tip. Under parts similar to adult. L 10.00—13.00; W., 8.00; T., 5.50.

Birds in adult plumage are rarely seen in Ontario.

Nest, in trees or on cliffs. Eggs, four or five varying from creamy white more or less heavily marked with reddish brown or chocolate.

GOSHAWK.

Adult. Upper parts bluish slate color; head almost black, a white line over and behind the eye. Tail like back and slightly marked with blackish; tip whitish; entire under parts evenly marked with irregular, wavy bars of grey and white, the feathers of the throat and breast with dark shafts.

Immature. Upper parts dark brownish, margined with rufous, primaries barred with black; under parts white or creamy streaked with black.

Male L., 22.00; W., 13.00; T., 10.00. Female L., 24.00; W., 13.40., T., 11.50.

Nest, in trees. Eggs, three to five, pale bluish white.

SHARP-SHINNED HAWK.

Feet extremely slender; bare portion of tarsus longer than middle toe; scutellæ frequently fused; tail square. Above dark brown (deepest on the head, the occipital feathers showing white when disturbed) with an ashy or plumbeous shade, which increases with age until the general color is quite bluish ash; below, white variously streaked with dark brown and rusty, finally changing to brownish red, with the white then only showing in narrow cross-bars, chin, throat and crissum mostly white with blackish penciling; wings and tail barred with ashy and blackish; quills white barred basally. Tail whitish tipped; bill dark; claws black; cere and feet, yellow.

Male L., 10-12; W., 6-7 T., 5-6. Female L., 12-14; W., 7-8 T., 7.

Nest, in trees. Eggs, four or five varying from bluish white to pale cream buff, distinctly spotted, blotched or even washed with reddish brown or chocolate.

COOPER'S HAWK.

Feet moderately stout, bare portion of tarsus shorter than middle toe; scutellæ distinct, colors and their changes as in the Sharp-shinned Hawk but the bird is larger and tail rounded.

Male L., 16-18; W., 9-10; T., 7-8. Female L., 18-20 W., 10-11; T., 8-9.

Nest, generally in an evergreen tree. The abandoned nest of some other large bird is often used. Eggs four or five, greenish white sometimes faintly spotted with brown.

BENEFICIAL HAWKS.

MARSH HAWK.

Adult Male. Upper parts grey or ashy. Upper tail coverts white; tail irregularly marked or barred with blackish; upper breast pearl-gray; lower breast and belly white spotted and barred with rufous.

Adult Female. Upper parts dark brownish, head and neck streaked and the wing coverts spotted or margined with rufous; upper tail coverts white; middle tail feathers barred with ashy and black, others barred with buff and black; under parts reddish buff streaked with dark brown.

Immature. Similar to the female, but somewhat darker all over.

Male L., 19.00; W., 13.75; T., 9.00. Female L., 22.00 W., 15; T., 10.00.

Nest, on the ground in marshes. Eggs, four to six pale blueish white.

RED-TAILED HAWK.

Adult. Dark brown above many feathers edged with tawny; four other primaries emarginate. Wing coverts not edged with rufous;

below creamy white streaked with various shades of brown, generally forming a broken band across the abdomen. Tail, rich chestnut-red with black band near the end and a narrow white tip.

Immature. Similar, but tail of same color as the back with distinct blackish bars.

Male L., 20.00; W., 15.50; T., 9.25. Female L., 23.00; W., 16.50; T., 9.75.

Nest in high trees. Eggs, two to four dull white generally scantily marked with rich brown of various shades.

RED-SHOULDERED HAWK.

Adult. Upper parts dark greyish brown, the feathers more or less edged with rufous. Bend of the wing, orange brown, forming a conspicuous "shoulder patch"; four outer primaries emarginate; tail blackish with four or five white cross-bars and white tip, throat streaked with blackish, rest of the under parts rufous everywhere barred with whitish.

Immature. Upper parts similar to adult; lesser wing-coverts margined with rufous, basal part of primaries mostly ochraceous buff, fading to whitish on the inner web with broken bars of dusky brown; tail dark greyish brown indistinctly barred, the inner webs of the feathers with white bars; under parts white with dark streaks.

Male, L., 18.30; W., 12.50; T., 8.00. Female, L., 20.35; W., 13.50; T., 9.00.

Nest, in trees. Eggs, four or five; dull white, generally blotched with reddish brown.

BROAD-WINGED HAWK.

Adult. Upper parts dark greyish brown the feathers more or less margined with buffy, those of the hind head and nape white at base; three outer primaries emarginate; tail with two or three dark bands alternating with narrow white ones. Below white variously streaked and spotted with rusty, the latter color predominating in some specimens.

Immature. Upper parts much as in adult; tail greyish brown, crossed with bands of dusky. Below dull white with longitudinal brown or dusky streaks on breast and sides.

Male, L., 15.89; W., 10.68; T., 6.75. Female, L., 16.76; W., 11.41; T., 7.09.

Nest, in trees. Eggs, three or four, dull white blotched or washed with various shades of brown.

AMERICAN ROUGH-LEGGED HAWK.

Adult. Head and neck whitish streaked with dusky upper parts brown, irregularly varied with white, grayish dusky or rufous; base of tail and upper tail coverts, white; rest of tail lighter brown, barred near the end with blackish. Under parts varying from white to buffy

streaked and spotted with black, these marks uniting to form a black abdominal zone. Legs densely feathered in front and on sides down to base of toes.

Immature. Similar to adult, but tail without bars except for the white tip. Under parts more heavily marked with black.

Black phase. Plumage more or less entirely black; primaries and tail barred with whitish and grayish.

L., 22.00; W., 16.00; T., 9.50.

The plumage of this species is very variable but it may always be distinguished by its large size and feathered legs.

Nest, on large trees or shelves of rocks. Eggs, two or three dirty white, blotched with reddish brown.

AMERICAN SPARROW HAWK.

Adult Male. Head slaty blue with generally a rufous spot on crown; a black mark before and behind the white ear coverts; back, chestnut red, with or without black spots or bars; tail chestnut red, a black band near its end; tip, white. Under parts creamy white to buff, with a few black spots or none.

Adult Female. Back, tail and wing coverts chestnut red barred with black; head as in the male; under parts more or less streaked with brown.

Immature. Resembles the adults.

L., 10.00; W., 7.30; T., 4.80.

Nest, in a hole in a tree. Eggs, four or five, very variable usually pale reddish buff, marked all over with reddish brown.

OWLS.

For some reason owls have always been treated with a certain amount of ridicule and contempt. In the minds of the ignorant and superstitious they were associated with cats and witches, and were supposed to possess a certain amount of influence with the latter, whose orgies they entered into with a great deal of spirit. In mythology, however, this bird was treated respectfully. Minerva, the goddess of wisdom, selected it as her attendant, and "as wise as an owl" has passed into a proverb by reason thereof.

Most of the owls seen in the day-time seem to be stupid, clumsy and inert creatures, as they sit winking and blinking in the unaccustomed light, striving as much as possible to shade their wonderful eyes from the too-powerful rays; but see these birds at dusk and after—what a transformation takes place! They are then as alert as any hawk; their soft plumage enables them to skim noiselessly around our farm buildings and over the fields in search of food, unlucky then is the mouse or rat that ventures to show itself, or even utter a squeak from its hiding place in the grass, (for owl's ears are as wonderfully constructed as their eyes, and their hearing is as acute as their sight). The fate of that mouse will be sealed, and it will vex the farmer no more.



Great Horned Owl.



Long-eared Owl.

Some of the owls however are day feeders—the Snowy Owl and the Hawk Owl I think entirely so—while the Great Horned Owl seems to be almost as active on dull days as at night; and whether the day be bright or dull these birds can always see well enough to take care of themselves and keep out of the range of a gun. In the cultivated portions of the Province of Ontario we have five species of owls that may be treated here as residents. They are not strictly so, as there is a certain migratory movement amongst them, caused probably by the failure or abundance of their food supply, which may cause them to either leave certain districts for a time or gather there in larger numbers than usual. Many instances are on record of plagues of mice having been stayed and the trouble removed by the arrival on the infested spot of large numbers of owls; these birds rapidly killed off the mice and then scattered again. Our resident species are the Great-Horned Owl, Long-eared Owl, Short-eared Owl, Barred Owl and Screech Owl.

The Great Horned Owl, or “Cat Owl,” as it is often called, is the only one I have ever known to attack poultry, and it can work havoc amongst them if they are left out to roost in unprotected places. The destruction of this owl is certainly justifiable and necessary where it has taken up its quarters in a locality in which poultry is kept. It also captures great quantities of our favorite game birds, more particularly Ruffed Grouse, many a brood of which goes to satisfy the hunger of the Horned Owl’s family, and are so lost to the sportsman. But as against the charge of poultry and game killing which has been proven against it, this owl has some redeeming qualities. It kills great numbers of rats, mice, squirrels and other rodents that are injurious to farmers, and strange to say it seems to be a determined enemy to the skunk. Numbers of cases have been cited in which the flesh and hair of this animal have been found in the stomachs of these owls, more particularly in the spring, and I know that fully one-half of the bodies of these birds that I have handled, were well perfumed with the odor of skunk—in many cases so much so, that I have had to throw away fine specimens the smell being quite unbearable. Possibly these birds are fond of strong odor, for those whose feathers are not scented with skunk perfumery, have generally a strong odor of muskrat, the flesh of which they also appreciate. I have frequently known them to hunt and kill these rats in the spring, during the day time when they were about the banks of the creeks, driven there by the high water of our usual spring freshet. These owls are very powerful birds, usually killing for themselves all the food they eat, and only resorting to carrion in the direst extremity of hunger. Turkeys and guinea fowls, from their habit of roosting in trees, frequently fall victims to the strength and rapacity of these creatures. In such cases only the head and neck of the slain will be eaten, the bodies being left to animals of less power, or meaner ambition, to finish.

The Long-eared Owl is a much smaller bird than the last (being about fifteen inches in length), and contents itself with much humbler

fare than its big cousin. It is fairly common through the cultivated districts particularly in the autumn, when it may often be found in clumps of willows and alders that have been left in the low places about the fields and pastures. Quite frequently a pair will be found together. These are not, however, always male and female. I have never seen any evidence to show that this owl attacks poultry, and I do not believe that it could kill any domestic fowl larger or stronger than a pigeon. Its chief food consists of mice, varied occasionally by small birds and insects, more particularly the wood-boring beetles; of these one or more will generally be found in the stomach of every specimen examined. It is nocturnal in its habits, rarely moving about during the day unless disturbed, and even then it seems loth to move. Only once have I seen it attempting to hunt in daylight, and that occurred in western Ontario on a very dull, still day in November, when about four o'clock in the afternoon I saw a pair of them hovering over a field of long grass into which we had driven a bevy of quail. I suspected the owls of quail-hunting on their own account so followed them and shot both, but their stomachs contained no trace of feathers—nothing but mice. The only harm these owls can ever justly be accused of doing is the occasional killing of a small bird, and that is so far overbalanced by the great amount of good they do, that they are entitled to all the protection possible.

The Short-eared Owl is about the same size as the last named species, but may be distinguished from it by the absence of the long ear-tufts, which are a conspicuous feature of the latter. This is probably the most abundant of all our owls, but it seldom frequents cultivated land, usually resorting to low-lying meadows and marsh hay lands. It is most commonly seen in the autumn, and appears to be somewhat gregarious, large numbers sometimes arriving at one of their feeding grounds together, and remaining there for a few days, then all move off again as they came, to be replaced after a short interval by another lot. The great bulk of them leave this Province by midwinter, or before if the snow should become deep, their movement towards the south being regulated entirely by the depth of snowfall. Whilst the ground is uncovered they are able to obtain a full supply of mice, which form the staple article of their diet; when the snow is deep the mice work underneath it. The supply being cut off, they are driven southward, whither the small birds have already gone, so they cannot fall back upon them. Unfortunately this is a bad failing with the Short-eared Owl—in fact my experience shows that it feeds upon mice and small birds indiscriminately, and what is worse, I am satisfied that it kills far more birds than it can eat. Near my home there is a large marsh partially surrounded by low meadows, which support a rank growth of grass, rushes and weeds of various kinds. This place is much frequented in the autumn by sparrows and warblers, migrating southward; in fact at times the place fairly swarms with them. Suddenly a number of Short-eared Owls will appear on the scene, and then numbers of small birds will be found



Short-eared Owl.



Screech Owl.

lying about dead, some partly eaten and others with only the skull crushed and a few feathers plucked off. At these times I have shot many of the owls, and found the crops and stomach to contain mice and small birds mixed. This will go on for a few days, or until the owls leave, and each morning the number of dead birds lying about will have increased. After the owls have gone the destruction ceases, only to begin again when the next lot of owls arrive. The small birds thus destroyed are of the greatest value to an agricultural community, and their loss is much to be deplored; but on the other hand the owls destroy an immense number of mice, so that the good they do probably balances the evil, and in such a case the best way is to let nature take its course without our intervention.

The Barred Owl is so rare with us that its influence on agriculture, either for good or ill, is practically nothing. The few I have found in this Province have always contained mice, but to the south of us, where the poultry are allowed to roost in trees, it is charged with occasionally killing half-grown chickens.

The noisy little *Screech Owl*, that may in some winters be found in half the barns in the country, is well known to every one, and should be protected by every farmer. It watches the granary, the barnyard and the garden, and is the most indefatigable mouser we have. It seems not only to kill mice for its immediate wants, but also for the pleasure of hunting them. If the roosting place of one of these birds is examined after the bird has used it for a short time, numbers of dead mice will be found, most of them untouched after being killed and deposited there; probably they lay up this store in order to provide against nights of scarcity, but in nearly all cases it will be found that they are well ahead of any danger of famine. Not only does this little owl rid the country of numberless mice, but in towns and cities it does useful work in keeping the common House Sparrow within proper limits. During the winter particularly, it may often be seen hunting about verandahs, under eaves, and among the Virginia creeper growing around dwelling houses, for the sparrows that roost there, and it will go regularly over the same beat night after night, until the accessible sparrows are thinned down, so that it finds it more profitable to change its hunting ground. Besides its great value as a destroyer of mice and House Sparrows, the Screech Owl eats a great many large beetles, particularly the wood-borers and May beetles, both of which classes of insects are capable of doing much injury if suffered to become too numerous. Grasshoppers also form a considerable article of this birds diet. The good qualities of this little owl cannot be over-estimated. Its food consists entirely of such creatures as are most injurious to the crops, and it has not a single evil habit. It should, therefore, be carefully protected, and encouraged to take up its abode in and about the farm buildings. This I believe it would readily do if it was left unmolested. All it asks in return for its valuable services, is peace and quiet, and a dark corner to roost in during the day.

The Great Gray Owl, the Snowy Owl, the Hawk Owl, Richardson's Owl and the Saw-whet Owl are only irregular visitors, usually occurring in the winter. The two first named are large birds whose food consists chiefly of game birds when in their northern home; here they feed upon the small rodents.

The island and sandbar to the south of Toronto is usually visited by a few Snowy Owls every winter. Here the birds feed upon the common house rats which are altogether too abundant at this spot. As every owl of any kind that visits the place is at once shot, the rats, having it all their own way, are increasing rapidly.

The Hawk Owl hunts by day, on the prairies of the Northwest, and where it occurs in sufficient numbers it must do much good by the destruction of meadow mice. Its visits to us are so rare, however, that it need not be considered here.

Richardson's Owl and the Saw-whet Owl are two little Owls that destroy many mice and noxious insects, but are too rare to need further mention.

Of the ten species of owls before mentioned, nine of them are among the best of the farmer's friends, watching and working when he is sleeping. In following out the natural law which governs their lives they greatly help to keep in check that vast army of little animals which, if allowed to increase unrestrained by their natural enemies, would in a few seasons destroy all vegetation on the face of the earth. The chief and most effective check upon the undue increase of this army of rats, mice, etc., are the birds of prey. These birds are endowed with natural faculties specially adapted for the work they do, and they do it well, the only trouble is that we have too few of them. If, however, public opinion can be brought to bear on this important matter before it is too late, and the wanton and useless destruction of our beneficial hawks and owls stopped at once, the balance of nature may be restored, to the great advantage of mankind.

The following shows the result of Dr. Fisher's investigation of the food habits of the owls as reported to the Department of Agriculture at Washington.

Great Horned Owl. 127 stomachs examined: 31 contained poultry or game birds; 8, other birds; 13, mice; 65, other mammals; 1, insects, etc.; 1, fish, and 17 were empty.

This shows that although the bird does some injury by its raids upon game and poultry, yet its evil propensities are somewhat counterbalanced by its destruction of mice, rats, rabbits and other small mammals. It is the only one of the owls about whose record for good there can be any doubt. All the others should be protected, while this one should certainly be killed off, if it takes to visiting the barnyard.

Long-eared Owl. 107 stomachs examined: 1 contained a game bird; 15, other birds; 84 contained mice; 5, other mammals; 1, insects, and 15 were empty.

Short-eared Owl. 101 stomachs examined: 11 contained small birds; 77 contained mice; 7, other mammals; 7, insects, and 14 were empty. My own experience shows a larger proportion of small birds than the above.

Barred Owl. 109 stomachs examined: 5 contained poultry or game birds; 13, other birds; 46, mice; 18, other mammals; 16, frogs, lizards, etc.; 16, insects, etc., and 20 were empty.

Screech Owl. 254 stomachs examined: 1 contained the remains of a pigeon; 38, other birds; 91, mice; 11, other small mammals; 25, frogs, lizards, etc.; 107, insects, etc., and 43 were empty.

The above examinations of the stomachs of our resident species show most positively that, with the exception of the Great-Horned Owl, the whole family are of the greatest value to the farmer. My own experience, both in Manitoba and Ontario, corroborates this, and is perhaps a little more favorable to the owls, for (always excepting the Great-Horned Owl) I have never found a trace of a game bird or domestic fowl in any of them.

DESCRIPTION.

OWLS.

GREAT HORNED OWL.

Ear. Tufts conspicuous, nearly two inches in length. Plumage varies greatly; in general the upper parts are mottled with varying shades of buff and brown; facial disc buff; a white collar on the throat, rest of the under parts greyish white or buff; barred with black. Legs and feet feathered. Eyes yellow.

L., 22.00; W., 15.00; T., 8.50.

Nest, sometimes in a hollow tree, a cleft in rocks or among the branches of a high tree, very often an old hawk's, or crow's nest is occupied. Eggs, three or four, round, white.

SCREECH OWL.

Adult; rufous phase—Ear-tufts conspicuous about an inch in length; upper parts bright rufous sharply streaked with black; under parts white, the feathers centrally streaked with black and irregularly barred with rufous.

Gray phase—upper parts generally brownish gray, streaked with black and finely mottled with buff; under parts white, finely streaked and more finely and irregularly barred with black.

Immature. Entire plumage regularly barred with grayish or rufous and white.

This owl may always be identified by its small size and ear-tufts. Its color phases are not dependent upon age, sex, or season and both phases are sometimes represented in the same brood. Between the

two there is a complete intergradation. In any phase there is a more or less conspicuous light stripe along each side of the back and a black line down the shafts of the feathers sometimes throwing out short transverse bars.

L., 9.50; W., 6.50; T., 3.09.

Nest, generally in a hollow tree. Eggs, four to six white, nearly round.

HAWK OWL.

No ear tufts; upper parts dark greyish brown more or less spotted with white, tail (long and rounded) barred with whitish; a patch of uniform black or dark brown on each side of hind neck. Under parts barred black and white.

L., 16; W., 9 T., 7.

Nest, in trees. Eggs, five or six; white, rounded, oval.

RICHARDSON'S OWL.

Adult. No ear-tufts upper parts grayish brown, the head and back spotted with white; tail with four or five imperfect white bars; under parts white, heavily streaked with grayish brown; legs and feet heavily feathered, whitish, barred with grayish brown; eyes yellow.

Immature. Upper parts dark cinnamon brown with a few more or less concealed white spots; tail as in the adult; breast like back; belly buffy.

L., 10; W., 6.75; T., 4.40.

Nest, in trees. Eggs two to four, white, nearly round.

SAW-WHET OWL.

Adult. No ear-tufts, upper parts, dark cinnamon brown, the head finely streaked, and back spotted with white; tail with three or four imperfect white bars; under parts white, heavily streaked with cinnamon brown; legs and feet heavily feathered, buffy white, unbarred; eyes yellow.

Immature. Upper parts as in the adult, but head and back with little or no white.

Nest, in hollow trees or old crow's nests usually, but sometimes among the branches of large trees. Eggs, two to four, nearly round, white.

GREAT GRAY OWL.

The largest Owl of this country. No ear-tufts; upper parts ashy brown, everywhere mottled with white; facial disc gray marked with dark concentric rings; under parts white, the breast barred and the belly broadly streaked with greyish brown; legs and feet heavily feathered; bill and eyes, yellow.

L., 25. to 30; W., 17.50; T., 12.50.

Nest, in evergreen trees. Eggs, two to four, white nearly round.

SNOWY OWL.

No ear-tufts. White, more or less barred with blackish markings. In some few males the dark marks are absent.

L., 25.00; W., 17.00; T., 9.50.

Nest, on the ground in Arctic regions. Eggs, four to seven, white, oblong oval.

LONG-EARED OWL.

Ear-tufts conspicuous, an inch or more in length, black bordered by white and buffy; upper parts brown mottled with white in small pattern the bases of the feathers buff; tail mottled and barred with dark brown; facial disc buff bordered by black. Under parts whitish and buff, the breast streaked with brown; sides and belly irregularly barred with blackish; eyes yellow.

L., 14.50; W., 11.90 T., 6.00.

Nest, sometimes in a thick evergreen, more frequently an old crow's or hawk's nest is occupied. Eggs, four to six, oval, white.

SHORT-EARED OWL.

Ear-tufts short, inconspicuous; upper parts buffy broadly streaked with dark brown; tail and quills, buff with dark bars; under parts buffy, the breast broadly streaked with brown, belly more finely streaked, but not barred; facial disc pale buff, eye patch, blackish.

L., 15.50; W., 12.75; T., 6.05.

Nest, on the ground in marshy meadows. Eggs, four to seven, nearly round.

BARRED OWL.

No ear-tufts; upper parts grayish brown, barred with white; tail and quill feathers barred ashly brown and white; facial disc gray, finely mottled; under parts white somewhat tinged with buffy, the breast barred and the sides and belly streaked with brown. Bill yellow; eyes brownish black.

L., 20.00; W., 13.50. T., 9.50.

INSECT DESTROYERS.

During the last twenty years the decrease in the number of small birds about our farms and gardens and the consequent increase of insect pests has become a cause of serious complaint.

Insects now affect every form of vegetable life. Borers work their way beneath the bark of the trees and cut long tunnels through the wood. Leaf eaters, by individual or combined attacks, often completely defoliate the trees. Curculios and grubs of various sorts enter the fruit, disfiguring it and rendering it useless, and weevils, with many other insects, attack our grain crops and despoil the farmer of the reward of his skill and labour.

While these species are at work upon the exposed portions of our plants, others, and by far the most injurious kinds, are beneath the soil boring into their roots, or eating away the fibres which provide them with nourishment, whilst the cut-worms, by severing the stalk at the surface of the ground, entirely destroy every plant they attack.

How to keep in check these insect pests is a question of the greatest possible importance to the whole community. It can be partly done, but at considerable expense, by our own labour, or it can be done at little or no cost, by intelligently encouraging and protecting our birds until they have increased sufficiently to restore the balance of nature.

Every class of our birds has its particular work to do, and the destruction or serious reduction in the number or individuals comprised in any class means a corresponding increase in the number of insects which it is the special mission of the birds to keep in check.

The Woodpeckers are wonderfully specialized to enable them to feed upon the borers that live in the trunks of trees. The Thrushes, Meadow Larks and Blackbirds feed principally upon such insects as hide just beneath the surface of the ground. Warblers, Orioles, Cuckoos, and many others, gather their food from among the branches, their prey consisting chiefly of leaf-eating caterpillars and beetles. The Flycatchers, from some post of observation, dart out and capture every winged insect that passes within their range; whilst the swallows and Night Hawks are constantly engaged in clearing the air of the myriads of flies and midges which, if not kept in check would render life almost unendurable.

SHRIKES.

Of this family we have two representatives in Ontario, the Northern Shrike which is a winter visitor, arriving in October and remaining here until the early part of April, and the Loggerhead Shrike, a summer resident, arriving in the early part of April, breeding here, and departing about the end of August. Both these birds, and in fact, the whole family of them, are generally known as "Butcher birds," all the species having the same peculiar habit of killing more victims than they actually require for their daily food, and spitting them on a thorn or twig near their resort. In their other habits these shrikes are much the same. When seeking food they generally perch on the top of some small tree, or a fence post, from which they can get a clear view all round them. Here they will sit in an erect, hawk-like attitude, silent and watchful until some large insect, a mouse or small bird comes within the range of their vision, when it is at once pounced upon and killed. If the shrike is hungry at the time, its prey is devoured at once, but if not the victim will be impaled upon some thorn, twig, or splinter in the vicinity. I have seen the barbs of a wire fence used for this purpose on the prairie, and

in places where bushes were scarce. Whether the shrikes ever eat these bodies or not I do not know. Probably they would do so in times of scarcity, but at any rate if a shrike's haunt is examined a good many specimens of its butchering will be seen perfectly dried up and past the stage when they were likely to afford any kind of nourishment. The shrikes are very handsome, bold birds, very fair singers and mimics. I have often heard the Northern Shrike imitate the screams of a small bird in distress, apparently for the purpose of attracting others to the spot, to see what the row was about, and no doubt the ruse would be successful, for it is the habit of all the smaller birds to flock to the place from which such cries proceed.

As the Northern Shrike is with us only in the winter it cannot be expected to feed largely upon insects, yet I have rarely examined the stomach contents of one of these birds, without finding at least the remains of a few beetles. When they first arrive in the autumn, however, their principal food consists of moths, grasshoppers, and such other insects as retain their vitality until frost comes. After that they feed upon mice and such small birds as remain here in winter; the House Sparrow forming a considerable portion of their fare.

I have never seen the Loggerhead Shrike kill a bird, nor have I ever noticed one hung up in its shambles, but it does destroy a great number of the larger insects and a good many mice. This is one of the very few birds that will eat the hairy caterpillars commonly known as "wooly bears;" of these the Loggerhead seems to be rather fond. I have often found them among its stomach contents, and on the 12th of April, 1899, I took a specimen the stomach of which was perfectly filled with them.

DESCRIPTION.

SHRIKES.

NORTHERN SHRIKE.

Adult. Upper parts clear bluish ash, becoming white on upper tail coverts and scapulars. A black bar along side of the head not meeting on forehead; forehead whitish. Wings and tail black; primaries white at the base, secondaries tipped with white; tail feathers tipped with white, the outer ones mostly white. Under parts white barred with fine wavy blackish lines; bill hooked and hawk like.

Immature. Similar, but entire plumage more or less heavily suffused with grayish brown.

L., 10.32; W., 4.50; T., 4.00.

Nest, in low trees or bushes. Eggs, four to six dull greenish gray, marked and spotted with obscure purple, light brown, or olive.

LOGGERHEAD SHRIKE.

Upper parts slaty gray, whitish on scapulars and upper tail coverts; wings and tail black, primaries white at base, secondaries tipped with white; tail feathers tipped with white, the outer one mostly white; a black bar on each side of the head, connected by a narrow black line across the forehead at base of the bill. Under parts always white.

L., 8.50; W., 3.80; T., 3.85.

Nest, in low trees or thorny bushes. Eggs, five or six similar to those of last species, but smaller.

SANDPIPERS AND PLOVER.

These two groups contain a large number of species most of which are of interest to sportsmen; but only four of them, two Sandpipers and two Plovers resort to the cultivated fields in Ontario. The others are chiefly birds of the sandy beaches and muddy margins of the marshes on which during the migrations they used to gather in vast flocks. Constant persecution has now so reduced their numbers, that the larger and more desirable varieties have become very scarce.

Bartramian Sandpiper. Though this bird is a true Sandpiper it seldom or never visits either the marsh or the beach. Its usual haunts are high dry grassy meadows and old pastures; or in the west the open prairie.

In Ontario it only occurs in a few localities and in small numbers. I have found it breeding in the Counties of Brant and Norfolk and on Amherst Island and Dr. Clarke reports it as breeding regularly near Kingston. In Manitoba where it is generally known as the Upland Plover it is sufficiently abundant to be of interest to sportsmen.

About the middle of May these birds return to their breeding grounds from the south and then may be heard the remarkable note of the male which differs so widely from any other sound in nature that even the most unobservant is attracted by it.

Early in August the Upland Plover leave us, drifting away towards their winter quarters in South America just when the insects which form their food, are in the greatest abundance, why they should do this, is one of the mysteries of migration as yet unsolved.

Spotted Sandpiper—Teeter. These birds arrive here about the beginning of May and at first confine themselves to the shores of our lakes and rivers where their graceful movements may easily be watched as they run rapidly along at the edge of the water stopping abruptly now and then to pick up an insect or go through the tail-wagging performance; after a week or so of this method of life during which they no doubt arrange their courtship and matrimonial affairs, they spread out over the country for the purpose of nesting, some few however remain in their lake or riverside haunts through the season.



Loggerhead Shrike.

I have found their nests in pasture fields, on summer fallows, in grassy orchards, fields of standing grain and on sandy beaches. One day as I was crossing a field of mangles I came upon a pair of Spotted Sandpipers with their brood of four chicks. Quicker than the eye could follow the little ones squatted down on the ground and were lost to sight while the mother bird feigned lameness and all sorts of injuries fluttering along just in front of me in order to decoy me from the vicinity of her downy treasures, taking care, however, to keep just far enough away to be safe. It is a strange instinct which impels certain birds to resort to this device in order to induce their enemies to follow them and abandon the search for their helpless young.

I do not suppose any person is ever deceived by the trick but four footed animals invariably are, even the wisest sporting dogs never seem to learn by experience but will dash headlong in hot pursuit after the apparently disabled old bird, which flutters enticingly before them, but always out of danger, until tired and panting the dog gives up the chase in disgust.

When on the ground this Sandpiper is as graceful and active as any of its tribe, but when on the wing its flight seems somewhat stiff and constrained, its wings do not seem to move with the same freedom exhibited by the other shore birds but for all that it is a remarkably swift and strong flier.

Its note (by which it may always be recognized) is a loud "tweet tweet" not very musical perhaps but on the shore it seems to harmonize with its surroundings.

From an economic point of view these birds are decidedly valuable; they feed upon nothing but insects, amongst which small beetles furnish the greater part. I once shot one in a pea field the stomach of which was filled with pea weevils.

DESCRIPTION.

SANDPIPERS.

BARTRAMIAN SANDPIPER.

Head and neck streaked with black and tawny; back and wing coverts, buff barred with black, primaries dark grayish brown, the outer one barred with white; throat, breast and sides pale buffy, the throat streaked, breast and sides with dark arrowhead markings and bars axillars and lining of wings white barred with blackish; under tail feathers brownish gray, outer ones varying from buff to white all more or less barred with black.

L., 11.50; W., 6.50; T., 1.90.

Nest, on the ground, often in a pasture field. Eggs four, pale clay color, spotted with reddish brown chiefly at the larger end.

SPOTTED SANDPIPER.

Adult. Upper parts grayish olive with a greenish lustre finely barred with black; white line over the eye; inner tail feathers like back, outer ones with blackish bars. Under parts white, everywhere spotted with black.

Immature. Upper parts much as in adult but colors and marks less distinct. Under parts pure white unspotted.

L., 7.50; W., 4.20; T., 2.

Nest, on the ground. Eggs, four, clay color, blackish with brownish-black markings.

GOLDEN PLOVER.

Golden Plover. Formerly vast flocks of this Plover visited Ontario every autumn, resorting to ploughed lands, pasture fields and sandy beaches for food. As they are, while here, purely insectivorous they form an important factor in the reduction of ground insects which abound in such places.

Unfortunately the birds are in great demand for the table and have been so relentlessly pursued by gunners that their numbers are seriously reduced.

In the spring Golden Plover pass Northward by way of the Mississippi Valley to their breeding grounds on the "barrens" of the Arctic Circle and so we do not see them, but during the fall flight they still appear on the farms, in some localities, in sufficient numbers to be of material service in ridding the fields of wireworms, cutworms and other insects exposed by the plough.

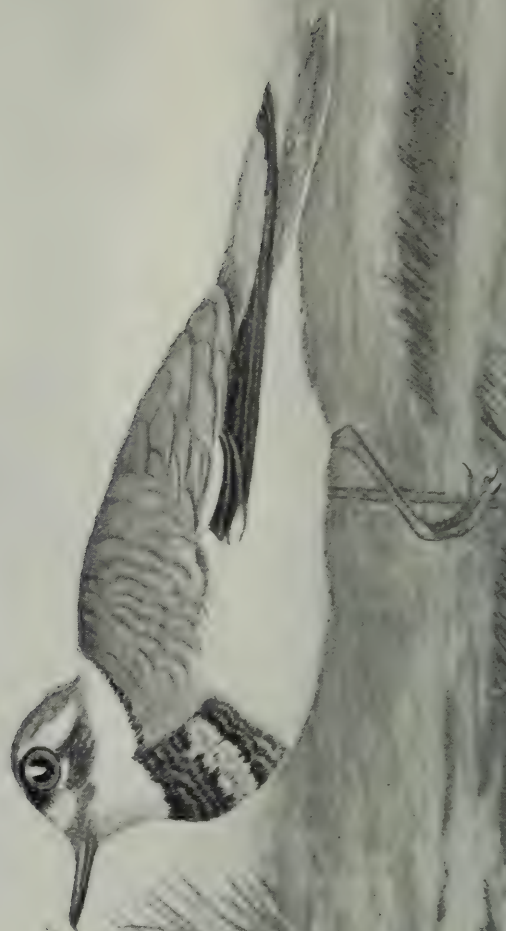
On the prairies of Manitoba they are abundant and are particularly partial to the burnt over lands. I have seen them in flocks of thousands following the fires; they will alight on the ground a few hours after the fire has passed and no doubt fare sumptuously upon the scorched and disabled insects they find among the charred grass roots.

Killdeer Plover. As soon as the ice is out the killdeer announces its return from the South by vociferously calling its own name as it circles about the water soaked fields, which are its favorite haunts from April to August.

It is an exceedingly active and graceful species more apt to run than to fly, if not too closely approached; but if followed up, it rises and dashes off rapidly on its powerful wings, uttering at the same time an alarm call which puts every wild thing in the neighbourhood on its guard.

The food of the killdeer consists of earthworms and insects of which small beetles form the greater part. A brood of these birds containing four young and the two parents, will relieve a farm of an enormous number of insect pests every day. I have frequently found the stomachs of these birds to be completely filled with weevils which they had obtained from orchards where clean cultivation had been practised. Towards autumn the broods leave the high, dry fields and gather into small scattered parties on river-side meadows and sandy shores where they remain until the first frost.

circus



PLOVER.

DESCRIPTION.

GOLDEN PLOVER.

Adult in summer. Upper parts mottled black, greenish, golden yellow and a little white, the yellow in excess; tail brownish gray indistinctly barred with whitish; sides of breast white; sides of head and under parts black; under wing coverts ashy gray. Bill and feet black. Toes three.

Adult in winter and immature. Upper parts and tail dusky, spotted and barred with yellow or whitish, the colours duller than in summer; under parts grayish white, throat and sides of head streaked, breast and sides of body mottled with dusky grayish brown; legs dusky.

L., 10.50; W., 7.00; T., 2.75.

Nest, on the ground, in Arctic regions. Eggs, four buffy drab spotted and splashed with very dark brown, chiefly at the larger end.

KILLDEER.

Above grayish brown, with a greenish tinge most of the feathers tipped with tawny; upper tail coverts bright rufous; inner tail feathers grayish brown outer ones rufous and white all tipped with black and white; secondaries mostly white; primaries with a white space; a black bar across the crown; forehead white; two black bands on neck and breast otherwise entire under parts white. Tail rounded at end; eyelids scarlet.

L., 10; W., 6.50; T., 3.50.

Nest, on the ground. Eggs, four, clay colour, heavily marked with blackish brown.

CROWS, BLACKBIRDS, ORIOLES, ETC.

Some of the species comprised in these two families of birds are charged with being amongst the worst of the feathered enemies of the farmer. The mischief they do is plainly visible; the good not always seen. When the Crow visits the corn field in the spring, and is seen digging into the hills, abstracting the half-sprouted grain, and when the Blackbirds in clouds alight on the ripe wheat and oats, eating much and threshing out more, so that it is lost to its lawful owner, it is not to be wondered at that the farmer loses his temper and says in his wrath that all birds are a nuisance; but these birds also do some good, though, as they have not acquired the knack of advertising it, their benefits are quite overlooked. If their case is tried impartially it may be found that even the Crow, like another celebrated personage, is not quite "so black as he is painted." I do not think the merits of the Crows, or any of the so-called blackbird family, will be found sufficiently great to entitle them to protection, but their faults scarcely warrant their extermination, except in the case of the cowbird, to be spoken of hereafter.

Raven. This species occurs only in the more northerly portions of the Province, having retired before the encroachments of civilization. To the pioneer it is sometimes a nuisance, poultry and young lambs falling easy victims to this bird's strength and rapacity. They also destroy a large quantity of game, but fortunately their number is so small, and the birds themselves so conspicuous, that it is not difficult to get rid of them.

Crow. Twenty-five years ago the Crows of the Province of Ontario were as regularly migratory as the Robins. A few occasionally stayed through the winter with us, and their doing so was considered a sign that we would have a mild season. As the land has been brought under cultivation, and more particularly in neighborhoods where market gardening is carried on extensively, the number remaining through the winter has steadily increased, so that the species may now be considered a resident one. In the vicinity of Toronto vast flocks gather at the close of the autumn, feeding on the refuse vegetables left in the market gardens outside the city, and resorting at night to some of the pine woods still left standing. In these they roost all through the winter. They may sometimes be pinched by hunger, but, unless the snow becomes too deep, they can generally get at the piles of manure drawn out on the market gardens, and other refuse left about the land. At this time they do no harm, and probably a little good as they pick up many mice and insects in their foraging, but when spring opens they again scatter over the country and seek their nesting places. Seeding operations are now going on, and the first of the Crow's mischievous propensities asserts itself. As soon as the grain has absorbed sufficient moisture from the ground to become soft and has slightly sprouted, then it becomes a favorite morsel for the Crows. Corn is preferred to any other grain. I have rarely found any quantity of any other grain in the stomach of a Crow, but even when the birds have been seen feeding among the hills of sprouting corn, and have been shot right on the spot, I have always found the stomach contained quite as large an amount of insect remains as of corn, the cut-worm forming one of the Crow's choicest articles of diet, and the question arises as to whether it is not better to let the Crow have a little corn and get rid of the cut-worm, than to let the cut-worm take off a lot of corn if we get rid of the Crow. Later on I will say something about the history of this same cut-worm. It is always wisest "of two evils to choose the least," and it must be conceded that the corn-eating propensity of the Crow is an evil; but it is certainly less than the evil done by the cut-worm. So perhaps, so far as the Crow's case goes here, it would be as well to call the balance even and give the Crow the benefit of it.

The next scene in the Crow's proceedings shows him with a lively and decidedly hungry family of four or five little ones, whose cravings demand constant attention from their parents. The variety of food supplied to these insatiable youngsters will vary somewhat according

to the locality in which they are placed. In any case, no more grain will be taken by the parent birds; their food now will consist entirely of insects, mice and the young of other birds. Nor will they stop at the young if they can catch an adult small bird. Sometimes they will try to elude the vigilance of an old hen, and will snatch up her chickens more adroitly than any hawk; ducklings fall easy victims to their cunning. It is at this season they do the greatest amount of mischief, by destroying the nests and young of more valuable birds, particularly of such as nest upon the ground. For this reason chiefly Crows should be kept within proper limits as to numbers. Of late years they have increased altogether too fast, and our small birds have suffered in consequence.

After the young birds leave the nest they move about with their parents and feed on the most varied diet. They will make a raid on the fruit grower, and demolish his cherries or raspberries if the idea strikes them, or they will prowl along the lake shore and enjoy themselves for a few days on fish fare, after which they will visit a pasture field and clear out all the wire worms, grubs and mice they may find there: in fact, very few things come amiss to them, as they roam about the country, until the cold nights warn them to get together in some place where they can get at least a bare subsistence to carry them over the winter.

As I have said before, Crows have increased too fast of late years, and we have now too many of them in the country; their numbers can easily be reduced if a little attention be paid to the matter in the spring. Just at nesting time they are less shy and wary than at any other season, and can be approached in the trees within shooting distance. If one of each pair were shot off their numbers would soon be reduced to such an extent that the damage they could do, would not be noticable. These birds are so well able to take care of themselves that even more stringent measures might be adopted against them without any danger of extermination, their natural enemies being very few, and those of that class against which man has carried on a most successful war. Of these the Great-horned Owl was the most noteworthy, but the Great-horned Owl will kill the poultry of a farmer who allows his fowls to roost out on winter nights, and so the Owl must go and the Crow has one enemy the less.

CROWS.

DESCRIPTION.

RAVEN.

Entire plumage black with glossy steel blue reflections; feathers on the throat narrow, long and pointed.

L., 22.00; W., 17.00; T., 10.

Nest, on high trees or cliffs. Eggs, four to six, pale bluish or olive green, spotted, blotched, or washed with purple or greenish brown; very variable.

AMERICAN CROW.

Entire plumage black, with blue, green and purplish reflections; the under parts duller; feathers on the neck short and rounded. Nasal bristles about half as long as bill.

L., 19.30; W., 12.20; T., 7.70.

Nest, in trees. Eggs, four or five, generally bluish green thickly marked with shades of brown, but very variable.

BLUE JAY.

Blue Jay. It is a pity that so beautiful and interesting a bird as this should be possessed of such mischievous propensities as it has, but I am afraid that neither its good looks nor its good acts can be said to balance its evil deeds. This bird, like the common Crow, seems to forget its usual shyness when spring arrives, and will leave its wooded haunts and build its nest in gardens, orchards and shrubberies, close to houses, and quite within reach of every person passing, nor does it affect any sort of concealment as a rule. I have seen many nests so placed that they were visible from public roads where people and vehicles were continually passing. The female could quite readily be seen sitting, yet the birds carried on their duties regardless of prying eyes. It seems a pity that their confidence should be abused, but I am compelled to say that in all cases that came under my observation the Blue Jays badly repaid the persons in whose gardens they were protected and allowed to raise their young. In the first place they steal a large amount of small fruit, and further, they rob and destroy the nests and young of other birds to such an extent that they are positively injurious to agriculture, the birds they destroy being all of that class whose food consists principally of insects, and without whose assistance I doubt if we could succeed in raising any crop to maturity.

The Blue Jays themselves, however, destroy no inconsiderable number of insects, and they do no damage to grain; they may occasionally pick off a little corn from the cob, but that is about the extent of the injury they do in that direction. Their unfortunate fondness for the young of other birds more valuable than themselves makes it necessary that they should be destroyed when they take up their residence about our gardens, for it is there, and in our cultivated fields, that our insectivorous birds do the most good; and to get them there we must give them as much protection as possible from their natural enemies, and teach them that they are in greater safety near our dwellings than they would be in the woods. Birds of all kinds soon lose their fear of man if unmolested by him, and particularly if they find that in his immediate neighborhood they can raise their young safely. I know of several farms and large gardens where the birds have been encouraged and protected from their enemies; to these places they return in increased numbers year after year, until nearly all



available breeding places are taken up. On these premises the owners rarely suffer from the depredations of cut worms or other insects, and so find themselves well repaid for the little care they require to exercise on behalf of their feathered friends.

Canada Jay, Whisky Jack. In Northern Ontario one of the commonest and certainly the most familiar bird of the region is the Whisky Jack. This fluffy, loose feathered creature—except at nesting time seems to have no fear of human-kind whatever, in fact seeks and enjoys their society. As soon as the settler puts up his shack and starts to cut a hole in the forest the birds will be his constant visitors, everything he does has an interest for them, from the felling of a tree which will expose some borers to the cooking of a dinner everything brings grist to the Whiskey Jacks mill and nothing comes amiss.

Like the Blue Jay this species is practically omniverous and in its native haunts is serviceable as a destroyer of insects and mice.

JAYS.

DESCRIPTION.

BLUE JAY.

Upper parts purplish blue; below pale gray; white on throat, belly and crissum; forehead, a band passing across the back of the head down the sides of the neck and across the breast black; head crested. Exposed part of wings and tail rich blue, with black bars, the greater coverts, secondaries and tail feathers, except the central broadly tipped with pure white.

L., 11.50; W., 5.15; T., 5.50.

Nest, in small trees or bushes. Eggs, four or five pale, greenish olive or sometimes clay colored, thickly spotted with olive brown. Very variable.

CANADA JAY—WHISKY JACK.

Back wings and tail dull leaden gray, most of the feathers of wings and tail narrowly tipped with white; fore part of head white, back of head and nape sooty black; throat and sides of the neck white, rest of the under parts ashy gray.

L., 12.00; W., 5.80; T., 5.80.

Nest, in coniferous trees. Eggs, four or five, light gray, finely marked at the larger end with dots and blotches of slate colour and brown, very variable.

Bronze Grackle, better known throughout the country as the "Crow Blackbird," is, when in full plumage, a very handsome bird, and may be distinguished from the other so-called blackbirds by its large size and the brilliant metallic lustre of its feathers. Like the Rook of Europe, it breeds in colonies, and is gregarious at all times of the year. To the farmer, the fruit grower and the lover of birds

generally, this bird is a nuisance. All that can be said in its favor is, that it is very beautiful, and that it does, at times, eat a large number of cut worms, for which it may often be seen working industriously on the lawns and grass fields near its nesting place; but as against that it has a heavy record of crimes to answer for. They are early migrants, arriving here about the end of March, and resorting at once to their nesting places. From this time until the oats are sown they probably feed entirely on insects, but as soon as the grain is in the ground they visit the newly sown fields and help themselves liberally, varying their diet by taking as many small bird's eggs and young as they can conveniently get at. I have on several occasions seen them attack and carry off young robins, in spite of the vigorous defence set up by the victim's parents and all the friends they could summon to their assistance. The row made by the despoiled nest owners on these occasions, together with the frantic dashes they made at the robber, would be sufficient to shake the nerves of one of the hawk family, but the Crow Blackbird disregards it all and goes off with its prey.

As soon as the strawberries, cherries, etc., are ripe these birds display a fondness for fruit and a persistency in gratifying it that is maddening to the fruit grower, whose profits dwindle day by day by reason of the visits of these thieves, who will continue to carry it off until the young leave the nest. When the young Grackles can fly they gather in large flocks and roam about the country all day, roosting together in vast numbers in some marsh every night. The Dundas marsh, near Hamilton, used to be much favored by them for this purpose; it is at this season they do the worst of their mischief to the fields of wheat and oats. Not only do they eat an immense quantity, but as they flutter and struggle in their efforts to balance themselves upon the straw of the standing grain they thresh out and cause the loss of much more. Nor does the cutting and shocking stop their ravages: they still continue to feed upon it until the last sheaf is in the barn. In the Province of Manitoba, where these birds are abundant, I have seen all the grain threshed out from the ears for a space of ten yards in width around fields which have been selected by them for their feeding ground. In this Province they are rarely to be found in sufficient numbers to do as much damage as that nor are they likely to become so, for although their chief natural enemies, the hawks and owls, have been too much reduced to be able to keep them entirely in check, yet their number is still manageable, and may be kept so by the judicious use of the gun. I advise any one who shoots them, particularly in the early autumn, to try blackbird pie. Whoever does so will, I think, want to repeat the experiment.

Rusty Grackle. This is a much smaller species than the last, and is not of any importance to us from an agricultural point of view. I merely mention it as it occurs here in considerable numbers for a short time in the autumn, but as it does not arrive until the early part of September, the crops are safe from its ravages. In Manitoba, where



Bronze Grackle.

it is very abundant, it unites with the other blackbirds and destroys a large amount of grain. A few pass through this Province in the spring on their way to the north to breed, but they make no delay and are not noticeable.

Red-winged Blackbird. From an agricultural standpoint this bird has little to recommend it, but to the lover of nature its beautiful coloring and cheery note in early spring render it an object of interest. They are among our earliest migrants, arriving about the middle of March, and resorting at once to the marshes, in which they remain until the young are able to fly. While in the swamps their food consists almost entirely of aquatic insects, of which the larvæ of the dragon flies form the principal part. As these larvæ form an important item in the food of some of our most valuable fish, and the mature dragon flies feed largely on mosquitos and other small winged insects, the blackbirds are not doing mankind a particularly friendly service by destroying them. This would perhaps not be worth sufficient consideration to warrant our interference with the birds were it not for their other and more serious failing. As soon as the young are able to fly strongly, which is about the middle of July they leave the marshes in which they were bred, and in great flocks resort to the grain fields, where like the Grackle, with which they frequently associate, they do much damage, particularly to oats, which they seem to prefer to any other grain. As these birds are very abundant, the loss caused by their plundering must be very great, but they can fortunately easily be managed if a little attention is paid to them in the spring, when they may be shot off on their breeding grounds.

After the grain is carried, they again return to the marshes, and gorge themselves on the wild rice, until not a grain of it is left, thereby depriving the wild ducks, etc., of a most attractive food. As soon as the first frost comes they retire to the south, where they cause much worry to the rice-grower. Little can be said in extenuation of these serious faults. They never interfere with other birds or their nests, and they probably destroy some noxious insects, such as cut worms, etc., in meadows, lying near the swamps they frequent in the early part of the season, but this is all that can be urged in their favor.

Cowbird. This bird should be known to everyone, and should be destroyed whenever the opportunity occurs. It is the only feathered creature against which I would advocate a war of extermination, and this I do, because it is not only of no value in itself, but the rearing of each one of its young means a loss to the country of an entire brood of one of our valuable insectivorous birds. It is true that during the early part of the season it frequents the pasture fields where cattle are grazing, and feeds principally on the insects affecting such places, but this is easily counterbalanced by the grain it destroys later on. These birds do not mate, nor do they build a nest for themselves, but the female deposits each of her eggs in the nest of some other small bird. The egg is whitish, thickly covered with greyish brown dots.

I have found the eggs of this bird in the nests of nearly all the sparrows, finches, and warblers that breed in the Province. After the egg of the Cowbird is deposited, the female takes no further interest in the matter, but leaves it to be hatched by the real owner of the nest in which it has been placed; in due time the young will appear and then the trouble arises. In a few days the young Cowbird has far out grown its fellow nestlings, in size, strength and voracity, so that it requires and manages to get all the food the parent birds bring to the nest, the result being that the proper occupants of the nest are either starved to death or crowded out by the interloper, which from that time until it is full grown taxes to the utmost all the energies of its foster parents to supply its voracious appetite. Nothing can be more pitiable than the plight of a pair of small birds upon whom one of these parasites has been foisted. They are forced to raise an ugly foundling instead of their own young and then by reason of the long continued helplessness of their foster child, they are prevented from raising a second brood; for although it quickly grows large and strong enough to crowd out its fellow nestlings, and its body develops rapidly, so that it can leave the nest and follow its foster parents through the trees, yet its energy does not develop proportionately with its body, and it requires to be fed for a longer period than the young of any other small bird. The destruction of the natural enemies of this bird, and the constantly enlarging area of cultivated land, both operate favorably for the increase of this pest, so that of late years it has become altogether too abundant. Of late years in the southern part of Ontario it has swarmed everywhere, and I notice an egg of this bird's in quite half the nests of other small species that I chance to find; of course in every case I take it out and promptly smash it, thereby saving the proper brood. It is to the increase of these creatures that I attribute almost wholly the decrease which has become so noticeable in our more useful species. Some idea may be obtained of the terrible destruction worked among the valuable species by Cowbirds, by just noticing the immense flocks of them that occur here in the autumn, and remembering that for every one of those Cowbirds, a brood of some other species has perished. Most of our insectivorous birds produce an average of about four young to the brood, and some of them would raise two broods in a season; the deposit of a egg by the Cowbird in a nest prevents the raising of any young at all of its own by the bird victimized. Just how many eggs each Cowbird lays each season is rather uncertain; in all probability four or five are deposited. If that is so, every female Cowbird that arrives here in the spring, and is allowed to follow her own method of reproduction, causes the loss of from fifteen to twenty-five of the young of our most valuable birds. In view of the great increase that has taken place in the numbers of this bird of late years, it is not to be wondered at that our other native species are decreasing, and we should take steps at once to regulate matters. Every person on finding a nest of any of our small birds



Cowbird.



Bobolink.



lunatic

Meadowlark.

should look over the eggs contained in it, and if one is found therein different from the others and corresponding to the description of the egg of the Cowbird which I have already given, that egg should be taken out and destroyed. School teachers throughout the country would do well to impress this upon their pupils.

Shooting the females in early spring is perhaps the most satisfactory way of keeping down the number of this most undesirable bird, and I strongly urge everyone who has access to a gun to use it for this purpose, about his own premises; for, as I have already pointed out, every Cowbird killed at this season means the salvation of much valuable bird life and a corresponding lessening of our insect pests.

Bobolink. One of the most familiar sounds of summer in the country is the merry rollicking song of the Bobolink, to be heard at all times in the fields of scent-laden clover; its bubbling notes, poured out in the exuberance of its spirits, seem to express the feeling of joy that pervades all nature in June. The birds arrive here about the middle of May, the males coming a few days before the females. They resort at once to the hay meadows, and remain there through the nesting season which is concluded by the time the hay is ready to cut. Whilst on the farms their food consists entirely of insects, of which the caterpillars that feed on clover form the greater part. These caterpillars are very abundant, and, where they are not kept in check by the birds, sometimes do serious injury, so that apart from its appearance, and its good qualities as a musician, the Bobolink has a claim upon us which entitles it to our best care and protection. After the hay is cut the males lose their black and white plumage, and become like the females and young in appearance, of a yellowish brown color. They then associate in small flocks and frequent the marshes, feeding on wild rice and the seeds of some rush-like plants until the first frosts come, when they retire to the south for the winter.

In the rice growing States these birds are sometimes accused of doing considerable mischief to the planters' crops, but I am inclined to think that the various species of blackbirds which also resort to these States are the principal depredators, and by reason of their greater abundance do the most of the damage.

Meadowlark. The Meadowlark is a common though, unfortunately, not now an abundant bird on the farm. Some years ago it could be found wherever the land was cultivated, all through the Province, but owing to its size and slow straight flight, which makes it an easy mark for the gunner, its numbers are decreasing very fast. This is a great pity, for it is an exceedingly valuable bird to the farmer. From the time of its arrival here in March until its departure in November it resorts to the cultivated land and grass meadows, feeding entirely on insects, and never indulging in grain or fruit of any kind. All its work being done amongst the crops upon which man expends his labor, and to which he is compelled to look for his subsistence, the benefit conferred is direct, and should be appreciated. We cannot make any return for the good it does, but we can at least

refrain from destroying its life, and exert ourselves a little to prevent others from doing so. The class of insects upon which this bird feeds during the early part of the season is perhaps the most injurious to vegetable life of all our insect enemies. Its food consists chiefly of those known as cut worms, wire worms, etc., all of which work underground for the most part during the day, and emerge from their hiding places at night only. By some highly developed faculty the Meadowlark is enabled to locate these creatures in their hiding places, and being provided with a sharp beak of sufficient length for the purpose, is able to drag them out and devour them. Of all the stomachs I have examined prior to July, the principal contents were wire worms, cut worms, and some few other caterpillars and beetles; later in the season the food consisted principally of grasshoppers. On two or three occasions I have found a few of these birds wintering with us, in the vicinity of market gardens, and being curious to know if at that season they had been compelled to fall back on a seed or vegetable diet, I shot one out of each lot, and I found the birds were in remarkably good condition. Their stomach contained, however, nothing but insects, chiefly bugs and beetles, which they had probably obtained from manure heaps and the refuse cabbages left in the gardens. These birds build a domed nest on the ground, in grass fields; their eggs and young are therefore liable to be destroyed by Crows, skunks and other vermin, and those that escape their natural enemies are subject to such continued persecution from gunners who ought to know better, that our beautiful Meadowlark is in danger of extermination, unless some effort is made for its protection.

ORIOLES.

Baltimore Oriole. The Golden Robin, Fire Bird, or Hang-nest, as the bird is sometimes called, is of more importance to the fruit grower than the grain farmer, as it gleans its food entirely among the branches, only visiting the ground for material with which to construct its purse-like nest. Its food consists largely of leaf-eating caterpillars and beetles. It is also particularly fond of the moths which frequent the trees for the purpose of laying their eggs; of these moths it devours large numbers, and in this way materially assists in keeping down the army of leaf eaters which so frequently strip our trees of their foliage. Very few of our birds will eat a hairy caterpillar, but when they eat a female moth before she has laid her eggs they destroy at one stroke a whole brood of these pernicious creatures, and to this work the Oriole devotes itself with great industry. I have on several occasions obtained a brood of young Orioles and hung them out in a cage near my house for the purpose of discovering the nature of the food brought to them, and found that fully one-half consisted of moths; unfortunately I did not keep a record of the number of these brought in any one day, but it was very large, and the usefulness of this bird in keeping down the swarms of destructive caterpillars, by cutting off the source of supply, was clearly exemplified.



Baltimore Oriole.

During the past summer (1900) I have received a number of reports as to the valuable work done by Orioles in clearing off Tent caterpillars. In several cases my informants state that they watched the birds at work in their orchards day after day destroying these pests and that in the end they completely cleared the trees of them.

A most interesting account of the operations of a pair of these birds was sent me by Mr. Yarwood, of Picton. He says: "A pair of "Baltimore Orioles delighted me this summer by building in a silver "maple in our door yard. As I was going in to breakfast one morning "when the caterpillars were but lately hatched and had small nests, "I saw an Oriole cleaning one of the little nests out. When I "came out after breakfast he had finished that nest and was engaged "on another. His appetite seemed to be immense. They must have "eaten an enormous number of insects for they raised four or five of a "brood. . . . I did not have to spray any gooseberries and currant bushes this year. I would notice branches that worms had "started on, but some enemy had devoured them."

When the cherries ripen the Oriole displays a certain partiality for fruit, but the small quantity they take may well be spared them, more particularly as it is only in this direction that they levy any toll for their services. The brilliant coloring of the male, his flute-like note, and the ingenuity displayed in the construction of the nest, all commend these birds to the lover of nature, and we could well spare a few cherries for the sake of having them about our gardens, even if their usefulness was less pronounced than it is. In the south-western portions of our Province the Orchard Oriole occurs. It differs from the Baltimore in being smaller, and in color being chestnut and black, instead of the orange and black which marks the present species. Its habits are much the same as those of the familiar Baltimore, but it is too rare to have any economic value.

DESCRIPTION.

BLACKBIRDS, ORIOLES ETC.

BRONZE GRACKLE—CROW BLACKBIRD.

Adult male. Head, neck, throat and upper part of breast, varying from brilliant metallic purple to bluish green or steel blue; back metallic bronze; wings and tail metallic purplish or blueish black, lower breast and belly similar to the back but duller.

Adult female. Much duller, the back and belly brownish, sometimes without metallic reflections.

L., 13.00; W., 6.00; T., 6.09.

Nest, generally in trees. The birds often nesting in colonies. Eggs four or five, lightish green or smoky blue, with irregular lines, dots, blotches and scrawls of purplish brown all over the surface; very variable.

RUSTY GRACKLE.

Adult male in summer. Entire plumage uniform glossy bluish black, tail feathers of nearly equal length.

Adult male in winter. Similar but the feathers of the upper parts widely tipped with rufous, the under parts similarly tipped with cream-buffy; a buffy line over eye.

Adult female in summer. Dark slate colour, glossy above, duller below; wings and tail darker and more glossy.

Adult female in winter. Similar but somewhat lighter, the upper parts tipped with rusty and under parts tipped with cream buffy.

L., 9.50; W., 4.60; T., 3.50.

Nest, on the ground or in trees or bushes. Eggs, four grayish or light green, very thickly covered with blotches and dots of purplish and reddish brown, very variable.

RED-WINGED BLACKBIRD.

Adult male. Uniform black; lesser wing coverts bright scarlet; middle wing coverts varying from buff to buffy white. In fall specimens the black is more or less tipped with rusty.

Female. Smaller under 8.00. Above blackish brown with pale streaks inclining on the head to form median and superciliary stripes; below, whitish with many sharp dusky streaks; sides of the head, throat and bend of wing tinged with yellowish red.

Male. L., 9.50; W., 4.70; T., 3.75.

Nest, usually fastened to the rushes in a marsh. Eggs, four or five pale blue curiously marked and scrawled with dark purplish brown.

COWBIRD.

Adult male. Head and neck, dark chestnut brown, the rest of the plumage glossy black with metallic reflections.

Adult female. Dull brownish gray, rather paler below, especially on the throat.

Immature in first plumage. Similar to the female but whiter below all the feathers edged with buffy.

Male. L., 7.90; W., 4.25; T., 3.05.

Nest, none. The eggs which are deposited in the nests of other birds are dull white, thickly dotted or sometimes blotched with brown.

BOBOLINK.

Adult male in summer. Top, sides of head and under parts black, the feathers more or less tipped with a narrow whitish or cream buff fringe which wears off as the season advances; back of the neck with a large creamy buff patch; middle of back generally streaked with creamy; scapulars, lower back, and upper tail coverts, soiled grayish white; wings and tail black; tail feathers with pointed tips; bill blue black.

Adult female. Upper parts yellowish brown streaked with black; crown blackish, with a central stripe of buff; wings and tail blackish, pale edged; under parts yellowish.

Male in the autumn. Similar to female.

MEADOWLARK.

Each feather of the back blackish margined with brownish yellow, neck the same but pattern smaller, crown streaked with black and brown a buffy line through the centre and over eye, a yellow spot over eye and a blackish line behind it; outer tail feathers mostly white, middle ones with imperfect bars or scallops of black brown and gray, sides of throat and ear coverts whitish; edge of wing and under parts generally bright yellow; a black crescent on the breast; sides and crissum pale brownish streaked with black.

Female. Similar smaller L., about 9.50.

Male. L., 10.75; W., 4.75; T., 3.75.

Nest, on the ground generally arched over. Eggs four to six, white spotted with reddish brown.

BALTIMORE ORIOLE.

Adult male. Head, neck, throat and back black; breast, belly, lower back and lesser wing coverts, rich, reddish orange; wings black, the outer margin of the greater coverts and quills edged with white; end half of middle tail feathers black, base orange; all the others orange crossed by a black band in the middle.

Adult female. Upper parts grayish orange, brighter on the rumps; head and back mottled with black, wings grayish brown; greater and middle coverts tipped with white, tail like the rump, the middle feathers stained with black, under parts dull orange.

L., 7.50; W., 3.50; T., 2.85.

Nest pensile, on trees. Eggs, four to six, white scrawled and dotted with fine black or reddish brown markings chiefly toward the larger end.

ORCHARD ORIOLE.

Adult male. Head, neck, throat, upper back black; breast, belly, lower back and lesser wing coverts chestnut; wings and tail dark grayish brown more or less edged or tipped with whitish.

Adult female. Upper parts grayish olive green, brighter on the head and rump; wings dark grayish brown, middle and greater coverts tipped with whitish, tail olive green; under parts dull yellow.

Immature male in first year. Similar to the female but back browner.

Immature male in second year. Similar to the female, but with the throat black and occasionally patches of chestnut on the under parts.

L., 7.35; W., 3.20; T., 2.95.

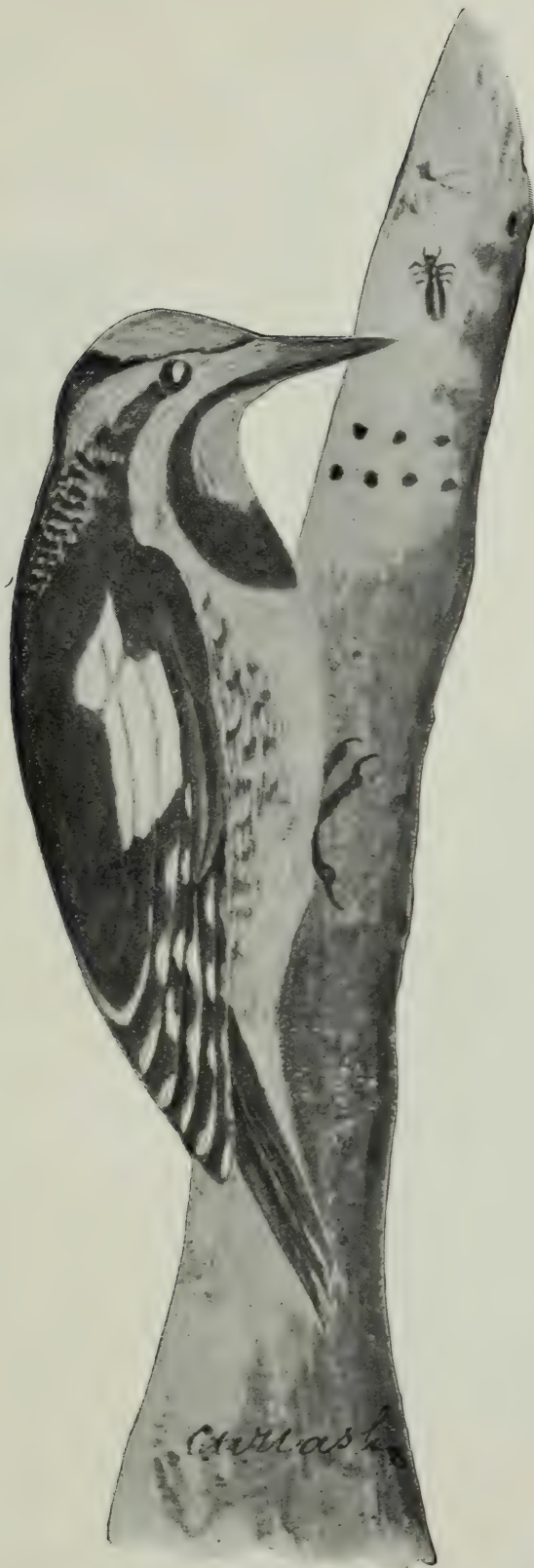
Nest, pensile, on trees. Eggs, four or five, bluish white spotted and scrawled with purplish brown and black.

WOODPECKERS, NUTHATCHES, TITMICE, ETC.

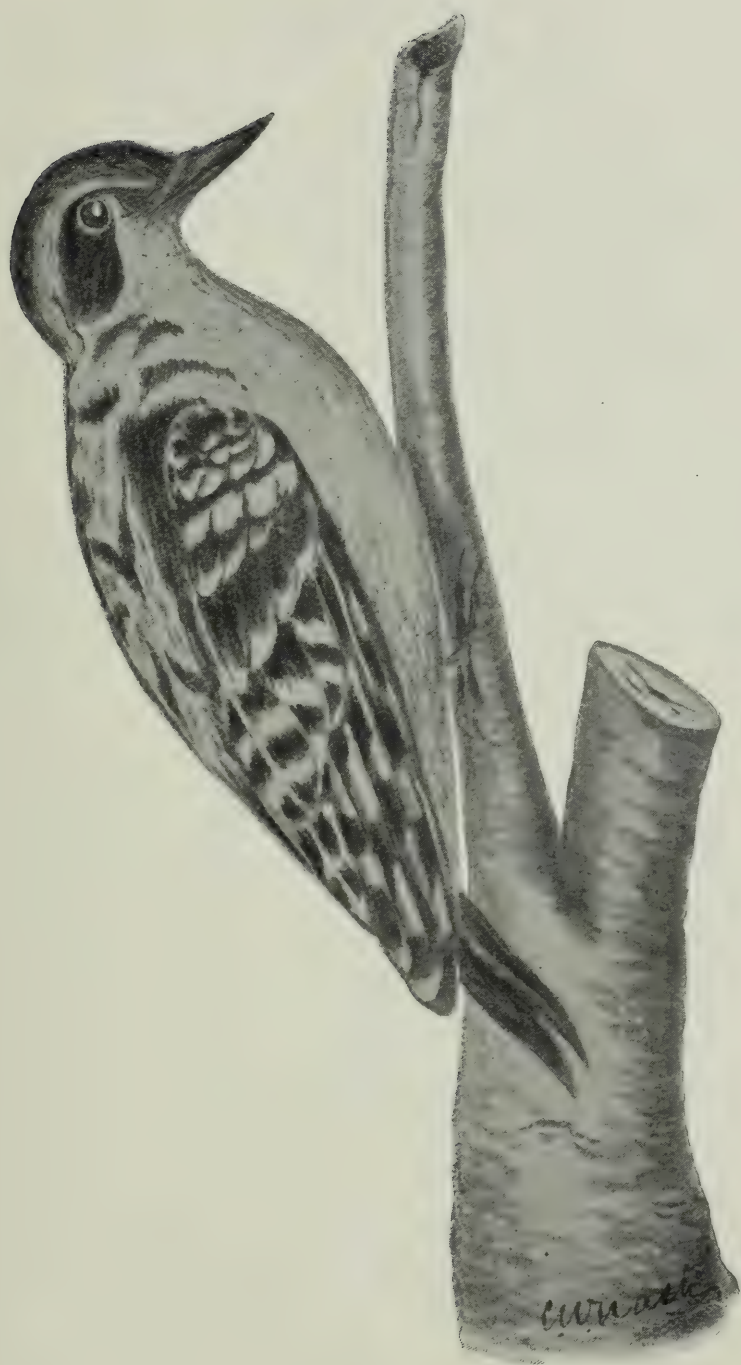
The various species which constitute these families have been grouped together, because of certain similarities in their habits, although structurally they differ widely. They are all tree climbers, and obtain the greatest part of their food from the trunks of trees, some of them by laboriously digging out the grubs which bore into the solid wood, others by prying into every crack and crevice of the bark, where they find insects in various stages of development.

Of the Woodpeckers we have in Ontario nine species, namely, the Pileated Woodpecker (better known as the "Cock of the Woods"), the Arctic Three-toed Woodpecker, the American Three-toed Woodpecker, Hairy Woodpecker, Downy Woodpecker, Yellow-bellied Woodpecker, Golden-winged Woodpecker, Red-headed Woodpecker, and Red-bellied Woodpecker. The first three are true birds of the forest, very seldom showing themselves in the neighborhood of cultivation, so that, although their services are of great value to the country, by reason of the constant war they carry on against the borers, which are so injurious to our timber, we need not consider them in this paper. The Hairy Woodpecker and the Downy Woodpecker are two species that almost exactly resemble each other both in habits and appearance, the only material difference being in their size, the Hairy Woodpecker measuring about nine inches in length, the Downy about six inches. Their food, which consists almost entirely of insects, is obtained either by digging the grubs out of the wood, or picking them out of the crevices of the bark in which they hide during the day. Sometimes during the winter I have found the stomachs of these birds filled with the seeds of the hemlock. These seeds seem to form a favorite food with many of our birds at this season; the berries of the sumach are also occasionally eaten by the little Downy, perhaps for the sake of the small beetles that are always to be found amongst them. These are the only two vegetable substances that I have ever known either of these species to feed upon.

Both these Woodpeckers are accused of injuring trees by boring holes in them to obtain a flow of sap, which they are said to drink. This is a mistake. The bird having the sap-sucking habit is the Yellow-bellied Woodpecker, an entirely different species, of which I shall speak presently. Nature has most perfectly fitted these birds for their task of ridding the trees of the grubs which bore into them. Their beaks are hard, sharp and chisel-like, so that they are enabled to enlarge the holes inhabited by these insects sufficiently to enable them to insert their long, barbed tongue, with which they extract the larvæ from their hiding places. In the winter these birds frequently visit the orchard, garden and shrubbery, and there they do most valuable work, by destroying the chrysalids of the moths that produce the leaf-eating caterpillars. The toughest cocoon ever spun by caterpillar is no protection against the sharp beaks of these birds, even the strong



Yellow-bellied Woodpecker—Sapsucker.



Downy Woodpecker.



Red-headed Woodpecker.

case which encloses the chrysalis of the large Cecropia moth is soon torn open when found by a Downy Woodpecker, and the contents devoured. Ants and borers in the trees are also greedily eaten by both species; in fact, nothing in the shape of insect life comes amiss to them, that can be found within their reach. The valuable work done by these birds for the protection of our trees should commend them to every lumberman, fruit grower and nurseryman, and though we cannot do very much to protect them from their natural enemies, we can cease destroying them ourselves and discountenance it in others.

The Downy Woodpecker may be readily attracted to an orchard in the winter season by baiting the trees with pieces of fat, in the same manner as is recommended for Nuthatches and Chickadees further on. The work done by this bird in extracting borers from the trees, and destroying the larvæ of the Codling moth, will amply repay a fruit grower for the small amount of attention necessary.

Red-headed Woodpecker. This is the most beautiful bird of the whole Woodpecker family, the strong contrast of the glossy black and the white of its body, and the brilliant crimson of the head of the adult birds, render them very conspicuous objects of the country; their value from an economic point of view, however, is debatable. From the time of their arrival here in May until the first strawberry ripens these birds feed on insects entirely, and in pursuit of their food they often adopt the tactics of the fly-catchers, by mounting to the top of a telegraph pole or bare limb of a tree, from thence darting out at any passing insect large enough to attract their attention. If the location selected is a favorable one and food abundant, they will remain at the same spot for some time; but after the small fruits ripen their tastes change, and they then visit the strawberry patches, both wild and cultivated, and cherries and raspberries are also eaten by them and carried to their young. When the season for small fruit is over they again resort to their insect eating habit, and so far as I have been able to observe, are not in this Province ever addicted to pilfering grain. I have occasionally seen an odd one make a raid on a vineyard and take a few grapes, and once or twice have seen them pick holes in apples, but the habit does not seem general.

There is no doubt that in the spring they do much good by destroying numbers of mature insects which, if allowed, would deposit eggs to produce vast numbers of injurious caterpillars. It is true also that in districts where small fruit is cultivated for profit they do much harm if they become sufficiently numerous. As the case now stands they are too scarce to do much injury and, except when they are too persistent in their visits to a garden or orchard, they may well be left alone. Although these birds are regular migrants, arriving here about the middle of May and leaving in September, I have once or twice met with them in sheltered woods in south-western Ontario in the winter, where their bright plumage showed to great advantage against the evergreens.

The habits of the Red-bellied Woodpecker are very similar to those of the above species, and its economic value about the same, but as it only occurs in the south-western counties of the Province, and then in very small numbers, it need not be further considered.

Golden-winged Woodpecker. Flicker, High Holder, Yellow Hammer, Pigeon Woodpecker, and half a dozen other aliases, testify that this is a well known, if not always a popular character. Like the last species, the value of this bird from the fruit-growers' standpoint is debatable, but it is not quite so much given to fruit eating as the Red-head, though when it has seven or eight hungry young ones to feed, and it finds a cherry orchard handy, it will help itself to a good many cherries, for which it has a decided predilection. Apart from this unlucky habit the bird has many good qualities. In some of its ways, it much resembles the Meadowlarks; like them it may often be seen on the ground searching for ants, of which it destroys vast quantities. I have often found their stomachs filled with them, and have rarely examined one without finding it contained some of these insects; it also devours great numbers of grasshoppers, beetles, moths, and other ground insects. This bird is really a ground feeder, for, though classed among the Woodpeckers by reason of certain similarities of structure, it does less woodpecking than any other of its class, the beak not being as well fitted for that operation as the beaks of the others. It has also the peculiarity of being able to perch crosswise on a branch, a method rarely adopted by its relations. There is one other evil trait that I have seen this bird exhibit, on two occasions only, that is the destruction by it of nests of the Bluebird; both the nests destroyed were built by the Bluebirds in holes in trees much higher than usual, probably from forty to fifty feet from the ground. I am not certain what the nests contained at the time, but I saw the woodpeckers pull out the nests and throw them piecemeal to the ground in spite of the resistance of the Bluebirds, but I found no trace of eggs or young; if there were any they must have been eaten. It is probable that the woodpeckers wanted the nesting site for themselves, and so dispossessed the owners. If so they were disappointed, for I settled the question by killing them, but I am sorry to say I omitted to examine the stomachs to see whether or not they had devoured the young Bluebirds, if there were any. I am inclined to think these were exceptional cases; they occurred over twenty years ago and I have never seen a repetition of the trick. If these birds become a nuisance in a garden or orchard, they can easily be killed off while they are committing their offence; but I think that through the country generally, the good they do, far overbalances the little damage they may do locally.

Yellow-bellied Woodpecker or Sapsucker. Adult male, crown and chin crimson, back and wing coverts black and white, wings black with large white bar, tail black, inner web of the two central feathers white with black spots, breast black edged with yellowish, the rest of the under parts dull yellowish, the sides white with black



Flicker.

streaks. In the female the crimson of the crown and chin is wanting, the crown is black, with sometimes a few traces of crimson on the forehead, the chin is white. I give a description of this species in order that it may be distinguished from the other small Woodpeckers, because it is principally owing to the propensity for drinking sap, which the bird has, that a certain prejudice exists in some localities against all the Woodpeckers, or Sapsuckers as they are called. It is quite true that this Woodpecker does in the spring, when the sap is rising, bore small holes in the bark of various trees for the purpose of obtaining the sap as it flows from them, and perhaps to attract the insects upon which they feed, to the same spot, so that they can satisfy their hunger and thirst without having to over-exert themselves in so doing. If life was not so short, I might be tempted here, to go into the question as to whether this bird had to acquire this habit, because its tongue was peculiarly fitted for it, or whether the tongue became modified so as to just suit the habit after the bird had acquired it; for the bird's tongue certainly differs from that of other Canadian Woodpeckers and is admirably fitted for the use to which it is put. A discussion of the question would exceed the scope of this article, and probably not lead to anything after all. We know the bird has this habit, and the question is, what is the effect of it upon the trees which are bored? I have made what observations I could, and as many enquiries from others as possible, and I have come to the conclusion that the only real damage done is that a young tree may be rendered unsightly for a time, or it may even be permanently disfigured by some peculiarity in the healing of the bark, but usually no harm ensues. That a tree ever was, or could be, killed by it I do not believe, for I have never yet seen or heard any evidence in proof of it. Further we know that Maple and Birch trees are tapped year after year for commercial purposes but the general health of the tree seems never to be adversely affected by doing so.

Apart from its sap drinking proclivity the bird's record is excellent; it is not a fruit or grain eater, but devotes itself to the destruction of insects that live on the trees or hide in the loose bark. Ants form a large proportion of its food. These it obtains from the rotten wood in which they burrow, as it does not descend to the ground in search of them. Beetles and moths are also sought out and devoured, but as this bird's tongue is not as well barbed as that of some of the other Woodpeckers, fewer grubs of the wood-boring class are eaten by it. I suppose if any man believes that these birds are doing an injury to his trees he should be allowed to protect himself in the only way possible, viz., by getting rid of the birds on his own premises; but for his own sake he should be sure he gets rid of the right one, and that neither the Downy nor the Hairy is destroyed by mistake. Both the Downy and the Hairy Woodpecker remain with us all through the year, whilst the Sapsucker is a summer resident only; so that whenever a Woodpecker is seen in the winter it should be spared, for it is most certainly a beneficial one.

WOODPECKERS.

DESCRIPTION.

PILEATED WOODPECKER—COCK OF THE WOODS.

Adult male. Upper parts dull black; top of the head brilliant scarlet, the feathers lengthened to form a crest, a white stripe borders this crest and separates it from the dusky ear coverts; a stripe beginning at the nostril and passing down the sides of the neck to the shoulders is tinged with yellow before the eye and is white behind the eye; a scarlet stripe at base of the lower mandible, basal half of the wing feathers white; under parts dusky black, the feathers sometimes slightly margined with white.

Adult female. Similar but with less scarlet on crown and none at base of lower mandible.

L., 17.00; W., 8.90; T., 6.25.

Nest, a hole in the trunk of a tall tree. Eggs, four or five, white, oval.

ARCTIC THREE-TOED WOODPECKER.

Adult male. Toes three, two in front. Middle of crown with a bright yellow patch; rest of upper parts shining blue black; wing feathers spotted with white; middle tail feathers black, outer ones white, except at the base; a white line from the nostrils passes below the eye; sides barred with black and white; rest of the under parts white.

Adult female. Similar, but without yellow patch on crown.

L., 9.50; W., 5.10; T., 3.40.

Nest, in a hole in a stub or tree. Eggs, four or five, white.

AMERICAN THREE-TOED WOODPECKER.

Adult male. Three toes, two in front; head spotted with white and a yellow patch on crown; back barred with black and white; wing feathers spotted with black and white; middle tail feathers black, outer ones black and white, region below the eye mixed black and white, sides more or less barred with black and white; rest of the under parts white.

LLL

Adult female. Similar, but crown spotted with black and white and without yellow patch.

L., 8.75; W., 4.55; T., 3.10.

Nest, in a hole in a stub or tree. Eggs, four or five, white.

HAIRY WOODPECKER.

Adult male. Back black with a long white stripe; wing feathers and coverts spotted with white; four middle tail feathers black, next



Pileated Woodpecker.

pair black and white, outer feathers white. A scarlet band on nape; crown and sides of head black with a white stripe over and another below the eye; under parts white.

Adult female. Similar but without scarlet on back of the neck.

L., 9.50; W., 4.80; T., 3.50.

Nest, in a hole in a tree. Eggs, four or five, white.

DOWNY WOODPECKER.

Adult male. Upper parts black, a long white stripe on back; wing feathers and their coverts spotted with white; middle tail feathers black, outer ones white, barred with black; a scarlet band on back of neck; wing feathers and their coverts spotted with white; a white stripe above and another below eye; under parts white.

Adult female. Similar but without scarlet band on nape.

L., 6.75; W., 3.70; T., 2.50.

Nest, in a hole in a stub or tree. Eggs, four or five white.

YELLOW-BELLIED WOODPECKER—SAPSUCKER

Adult male. Crown scarlet; back irregularly barred with black and yellowish white; wing feathers spotted with white, their coverts mostly white; tail black, the middle feathers with broken black bars the outer ones with white margins; a white line from the bill passes below the eye; throat scarlet; breast black; sides streaked with black; belly pale yellow.

Adult female. Similar but throat white; crown sometimes black; outer tail feathers with broken white bars.

Immature. Similar to adults, but with the crown dull blackish, the breast brownish gray, barred with black, the throat whitish.

L., 8.50; W., 4.80; T., 3.15.

Nest, in a hole in a tree. Eggs, four or five, white.

GOLDEN-WINGED WOODPECKER—FLICKER HIGH-HOLER.

Adult male. Top of head ashy gray, a bright scarlet band across back of the neck; back, wing coverts and innermost quills brownish gray, thickly barred with black; tail coverts white barred with black; primaries black externally, inner surface of wing and shafts of the feathers bright yellow; tail black above, below yellow, tipped with black; sides of the head throat and upper breast vinaceous; a broad black stripe on either side of the throat from the base of the bill and a broad black crescent across the breast; rest of the under parts white more or less tinged with vinaceous and thickly spotted with black.

Adult female. Similar, but without the black streaks on the side of the throat.

L., 11.00; W., 6.00; T., 4.00.

Nest, in a hole in a stub or tree. Eggs, five to nine white.

RED-HEADED WOODPECKER.

Adult male and female. Head, neck and upper breast deep crimson; back, primaries, bases of the secondaries and wing coverts glossy blue black; end of secondaries rump and upper tail coverts white; tail black the feathers more or less margined with white; lower breast and belly white, generally tinged with reddish.

Immature. Head, neck and upper breast grayish brown; upper back bluish black barred with ashy; primaries and wing coverts black; end half of secondaries irregularly barred with black; tail black generally tipped with white; lower breast and belly white, more or less streaked or spotted with gray.

L., 9.25; W., 5.50; T., 3.25.

Nest, in a hole in a tree. Eggs, four to six white.

RED-BELLIED WOODPECKER.

Adult male. Whole top of the head and back of the neck bright scarlet; back regularly barred with black and white; primaries black at the end, white irregularly barred with black at the base; secondaries black, regularly spotted and barred with white; upper tail coverts white, with streaks or arrowheads of black; outer tail feathers and inner vanes of the middle ones irregularly marked with broken black and white bars; cheeks and under parts dull ashy white, the region about the base of the bill, the middle of the belly and sometimes the breast more or less tinged with red.

Adult female. Similar but with the crown grayish ashy, the scarlet confined to the nape and nostrils.

Immature. Similar, but with the belly sometimes tinged with buffy instead of red.

L., 9.50; W., 5.00; T., 3.50.

Nest, in a hole in a tree. Eggs, four to six white.

Nuthatches, Chickadee, and Tree Creeper. Of these we have two species of Nuthatches—the White-breasted and Red-breasted,—two Chickadees and one Creeper. They are all resident species, though more frequently seen around cultivated lands in the winter than in any other season. They are among the most active insect destroyers we have, gleaning their food from the bark, branches and leaves of trees, and seldom descending to the ground, though when wood-chopping is going on in the bush the logs, sticks, and chips will all be carefully searched for grubs which have been exposed by the axe. The familiarity displayed by these little creatures at this time is very pleasing. As soon as work begins, and the first few strokes of the axe sound through the bush, they gather round and investigate every piece of bark and decayed wood thrown open, and from each one gather some prizes. It is very amusing to watch the little Chickadee when he finds a large grub of one of the borers partly exposed. He

pulls and tugs at it until it comes out, and then securely holding it down with his feet he tears it in pieces and devours it. Without the assistance of the chopper it is but seldom that they can get at the larger grubs that bore deeply into the solid wood, as they have neither the strength nor proper tools for digging them out; but they have found that when the farmer cuts his cordwood their opportunity for a feast arrives, and so they take advantage of it. As a general rule, however, they scour the bush, orchard, and shrubbery in merry little parties searching for food, from time to time uttering their musical notes, which always have a peculiar "woody" quality about them. The seeds of the hemlock are occasionally eaten by the Chickadee and the Red-breasted Nuthatch, and the White-breasted Nuthatch is said to sometimes eat beechnuts and acorns, but I have never found any trace of them. The Tree Creeper eats no vegetable substance whatever.

This little group of birds is of the greatest value to the fruit-grower, as they feed principally on the minute insects and their eggs, which are individually so small that they escape our observation until, having seen the damage done by them, our attention is called to their existence, and then it is too late to enable us to remedy the matter for the season.

In the winter season fruit-growers should endeavour to encourage birds of this class to resort to their orchards, for they are among the most effective checks upon injurious insects that we have.

They destroy immense quantities of eggs from which the tent caterpillar, the canker-worm and aphides are produced. The larvæ and pupæ of the codling moth are also eagerly sought for and devoured.

When you see these little birds scrambling about the trunks and branches of your trees, peering sharply into every crevice of the bark, it is these insects they are looking for, insects and their eggs that at this season are generally so well hidden that only the birds' sharp eyes can detect them. They do, however, find enough of them to supply their wants, and thereby save the trees from much damage the following season.

The best way to induce the birds to remain in and about an orchard is to hang up among the trees a few bones with some fat on them, or a few lumps of fat tied to the branches here and there will have the desired effect. The birds will soon find them out, and if the supply is kept up will remain in the neighborhood all the season. Feeding on this will not prevent their insect hunting, but will obviate the necessity for their wandering over too much ground, and they will concentrate all their efforts upon the trees where they are sure of finding food.

A remarkable example of the benefit that may be derived from the presence of a flock of Chickadees has been recorded by Mr. E. H. Forbush in a bulletin of the Massachusetts State Board of Agriculture.

In a certain orchard in Massachusetts the canker-worm moth had deposited great numbers of eggs upon the trees. Pieces of bone and fat were fastened to the trees early in winter to attract the Chicka-

dees. The birds came and remained about the orchard nearly all the winter. They were carefully watched and it was found that they were feeding on the eggs of the canker-worm moths. A few birds were killed to determine the number of eggs eaten. Between two and three hundred canker-worm eggs were found in the stomach of each of these birds. In the spring the female moths of the spring canker-worm were also devoured. The result was that the Chickadees, assisted in spring and early summer by some other birds, saved the orchard from any serious injury by the canker-worms.

NUTHATCHES—TITS—TREE CREEPER.

DESCRIPTION.

WHITE-BREASTED NUTHATCH.

Adult male. Crown and nape glossy black; back rump and middle tail feathers ashy blue; outer tail feathers black, with white patches near the tips, inner secondaries bluish gray, marked with black; wing coverts and quills tipped with whitish; sides of head and under parts white, lower belly and under tail coverts mixed with rufous.

Adult female. Similar but the black of head and neck duller.

L., 6.00; W., 2.70; T., 1.95.

Nest, in a hole in a stub. Eggs, five or six white streaked with reddish brown.

RED-BREASTED NUTHATCH.

Adult male. Crown shining black, bordered by a white line over the eye, a black line from the bill through the eye to nape widening behind the eye; upper parts bluish gray; outer tail feathers black, with white patches near their tips, middle ones bluish gray; throat white rest of the under parts rusty red, sometimes reddish buff.

Adult female. Similar but top of head and line through eye, dark bluish gray.

L., 4.65; W., 2.65; T., 1.65.

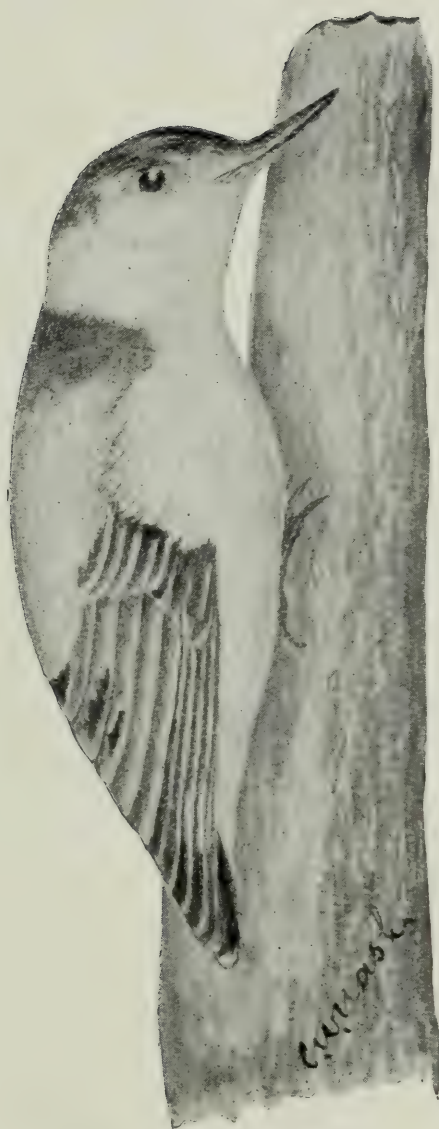
Nest, in a hole in a tree or stump. Eggs, five or six white, specked with reddish brown.

CHICKADEE.

Crown, nape and throat, black; sides of head and neck white; back ashy gray; wing and tail feathers margined with whitish; breast white; belly and sides washed with pale buff.

L., 5.25; W., 2.50; T., 2.50.

Nest, in a hole in a stump or tree. Eggs, six to eight; white spotted and speckled chiefly at the larger end with reddish brown.



White-breasted Nuthatch.



Wood Thrush.

TREE CREEPER—BROWN CREEPER.

Upper parts curiously marked with brown, buff and white, rump pale chestnut; wings dusky, marked with tawny and white and with a band of creamy buff; tail dusky, the feathers sharply pointed; under parts white; bill slightly curved.

L., 5.50; W., 2.60; T., 2.65.

Nest, generally in a crevice behind the loose bark of a tree. Eggs, five to eight, white speckled and spotted with reddish brown, chiefly in a wreath at the larger end.

THRUSHES.

We have in Ontario seven species belonging to this family, all of them migratory, arriving here from the south in early spring and leaving us in the autumn, as cold weather sets in. They are the Wood Thrush, Wilson's Thrush, Grey-cheeked Thrush, Olive-backed Thrush, Hermit Thrush, Robin and Bluebird. The Olive-backed Thrush, Hermit Thrush, and Grey-cheeked Thrush pass on and raise their young to the north of us; the others remain throughout the summer and breed here.

The Wood Thrush and Wilson's Thrush, or Veery, as it is sometimes called, are strictly birds of the woodlands, and seldom venture far from the edge of the bush, though both species will at times select a garden where there are shrubs for their summer residence, if they find themselves unmolested, particularly if there are no domestic cats about the premises. The cats at all times prefer young birds to mice or rats, and are as much to blame for the decrease of our native birds as bird-nesting boys or anything else, perhaps, except the Cowbird. Wilson's Thrush is one of our most abundant species, but it has the faculty of concealing itself to such perfection that it is often overlooked, though there may be many within a few yards of where a person is standing. The Wood Thrush is very rare with us, which is to be regretted, as it is a beautiful songster.

All these thrushes are very valuable birds to the agriculturist, their food consisting for the most part of grubs that live under the surface of the ground, and caterpillars. In the autumn they eat many wild berries, those of the Elder and Viburnum being especial favorites, but they never help themselves to the produce of the farm or garden. The best known and most familiar of the thrush family is the Robin, and opinion is very strongly divided as to its utility. Many fruit growers condemn this bird with great emphasis, stating that it is the worst enemy they have; others weigh its merits and demerits more carefully, and are inclined to think that it at least pays for the fruit it eats by the destruction of insects. No doubt it does take a large number of cherries, strawberries, and raspberries, and some grapes, but it is open to question if it were not for the birds whether there would be any cherries, strawberries, grapes, or, indeed, whether any crop

could be brought to maturity. The great merit of the Robin is, that in the early part of the season it feeds itself and its young almost entirely on cut worms, and on the large white grub, the larvæ of the May beetle. Of all our insect enemies the underground cutworm is about the most destructive, for in feeding it just comes above the surface and cuts off the entire plant; or if the plants are very young and the stems small it cuts off half a dozen or more at one time, only eating a small section out of the stem of each, and leaving the plants dead on the surface of the ground. Whole rows of peas, corn, beets, cabbage, and cauliflower are often so treated; tomatoes, too, fare badly with them. In 1908 one farmer near Jordan lost over six thousand tomato plants by the ravages of the cut worm and many others in the fruit growing districts suffered almost as severely. The only remedy that seems effectual against their attacks is to wrap paper around the stems of the plants from the surface of the soil to the height of about three inches above it. This is obviously impossible in the case of field crops, and it is equally impossible to go over the fields and take the worms out by hand, so that we must rely, for the most part, upon the ground feeders amongst the birds; these are fitted by nature for digging out the insects and devouring them.

Robin. Among the most conspicuous of these birds is the Robin, and one need only watch one of them at work in the garden, from April to about the middle of June (which is the season of the cut worm's activity) to be satisfied as to the Robin's good work. I will give the result of an experiment carried on by myself which shows the number of these insects a pair of Robins will destroy when they are feeding a brood of young. In May, 1889, I noticed a pair of robins digging out cut worms in my garden, which was infested with them, and saw they were carrying them to their nest in a tree close by. On the 21st of that month I found one of the young on the ground, it having fallen out of the nest, and in order to see how much insect food it required daily I took it to my house and raised it by hand. Up to the 6th of June it had eaten from fifty to seventy cut worms and earth worms every day. On the 9th of June I weighed the bird; its weight was exactly three ounces, and then I tried how much it would eat, it being now quite able to feed itself. With the assistance of my children I gathered a large number of cut worms and gave them to the Robin after weighing them. In the course of that day it ate just five and one-half ounces of cut worms. These grubs averaged thirty to the ounce, so the young Robin ate one hundred and sixty-five cut worms in one day. Had it been at liberty it would probably have eaten some insects of other species and fewer cut worms, but this shows near about what each young Robin requires for its maintenance when growing; the adult birds require much less, of course. The average number of young raised by a Robin is four, and there are usually two broods in the season. A very simple calculation will give a good idea of the number of insects destroyed when the young are in the nest. After the young have flown they are apt to visit the small fruit and



Robin.

it is no doubt very provoking to find a flock of them helping themselves to strawberries, etc. If possible, they should be kept off without destroying them, a resort to the gun being avoided as long as possible.

Bluebird. Twenty years ago the Bluebird was one of the most abundant of the summer residents in the cultivated districts of the Province; there was scarcely a farm throughout southern Ontario upon which two or more pairs of these birds did not breed. The same birds seemed to return regularly to occupy their holes in the old apple trees and fence posts, year after year, and so familiar were they that they actually seemed to know the members of the family whose premises they occupied. In one case, near Niagara, a pair of Bluebirds, for several years in succession, built their nest in a letter box which was placed at the gate of the farm, opening on the main road. The mail carrier deposited letters and newspapers in the box every day, which were duly taken out by the members of the family. To all this the birds paid no attention whatever, but would confidently sit upon their eggs or visit their young while the box was opened and people stood close to them; and I have seen many similar instances of confidence on the part of these birds.

Of late years the Bluebirds have not remained with us, and they have been much missed. Enquiries are constantly being made as to where the Bluebirds have gone. That is not so easy to answer, but that they still exist in undiminished numbers I am able to state positively, for so late as last March (1901) I saw many thousands passing over Toronto from west to east. The flight lasted from daylight to nine or ten o'clock every fine morning for about a week. I have seen this same movement every spring for years. My opinion is that the birds have gone back to the new settlements, where they can still find snake fences, and pastures in which the old stumps are standing—our modern barbed wire which has taken the place of the old stake and rider fence having deprived them of a favorite nesting place. The up-to-date fruit grower, too, no longer allows his apple trees to go untrimmed and full of holes, but cuts out the old trees and replaces them with young ones. This has removed many of the old nesting sites, and the birds have spread out over the large area of new country now being brought under cultivation. They introduced themselves to the Province of Manitoba about 1884, and have since become quite common there, having evidently followed the settlers, as they were quite unknown in that country before it was brought under general cultivation. The utility of this bird as an insect destroyer is beyond question. It eats neither grain nor fruit; occasionally in stormy weather, in early spring when insect food is hard to obtain, it will eat the berries of the sumach, but that is the only vegetable substance I have ever known it to take. The beauty of its plumage, its sprightly spring song, and even the rather melancholy farewell notes in which it bade us good-bye, as it drifted southward in the last days of October, made it a great favorite everywhere, and every lover of nature would be glad to see it return and take its old place about the farm once more.

Nest boxes placed in the orchards too low down to tempt the House Sparrows to occupy them, would probably induce the Bluebirds to remain with us.

THRUSHES.

DESCRIPTION.

WOOD THRUSH.

Upper parts bright rufous brown, brightest on the head, and changing gradually to pale olive brown on the upper tail coverts and tail; under parts white, thickly marked with large round black spots except on the throat and middle of the belly.

L., 8.25; W., 4.40; T., 3.00.

Nest, generally in low tree or sapling. Eggs, four or five, greenish blue.

WILSON'S THRUSH—VEERY.

Upper parts, wing and tail nearly uniform tawny not so bright as in the Wood Thrush; centre of the throat white, sides of the throat and breast with a tinge of buff, spotted with small wedge shaped dusky spots, the breast with half round marks of same colour.

L., 7.55; W., 4.06; T., 3.00.

Nest, generally in low bushes. Eggs, four or five, greenish blue.

GRAY-CHEEKED THRUSH.

Upper parts uniform olive (no buffy tint about the head) eye-ring whitish, lores grayish; middle of the throat and middle of belly white; sides of the throat and breast, with a very faint tinge of cream buff; sides of the throat spotted with wedged shaped marks, the breast with half round black marks.

L., 7.58; W., 4.09; T., 3.00.

Nest, in low trees or bushes. Eggs, four or five, greenish blue spotted with rusty brown.

OLIVE-BACKED THRUSH.

Upper parts uniform olive, sides of head, throat, neck and breast strongly tinged with buff; eye-ring deep buff; sides of throat marked with wedge shaped spots, the breast with rounded black spots.

L., 7.20; W., 3.95; T., 3.00.

Nest, in bushes or small trees. Eggs, three or four, greenish blue speckled with reddish brown.

HERMIT THRUSH.

Upper parts, cinnamon brown. tail rufous of a decidedly different colour from the back; throat and breast with a slight buffy tinge;



Catbird.

feathers of the sides of the throat and breast with wedge shaped black spots, those of the breast with large rounded spots; middle of the belly whitish.

L., 7.25; W., 3.25; T., 3.00.

Nest, on or near the ground. Eggs, greenish blue.

AMERICAN ROBIN.

Adult male. Top and sides of head black; a white spot above the eye, rest of upper parts slaty gray; tail black the outer pair of feathers, white tipped; throat white, with black spots; breast and sides rufous, the feathers sometimes slightly margined with white; middle of belly white.

Adult female. Similar but much duller and paler.

Immature. Darker brown and spotted above and below.

L., 9.75; W., 5.00; T., 4.00.

Nest, in any convenient place, most frequently in trees. Eggs, four or five, greenish blue.

BLUEBIRD.

Adult male. Upper parts uniform bright blue, the feathers sometimes irregularly margined with rusty; throat breast and sides dull rufous; belly white.

Adult female. Similar but much duller.

Immature. Back spotted with whitish; the feathers of the breast margined with grayish brown.

THRASHERS AND MOCKERS.

Catbird. Neither this nor the succeeding species belong to the Thrush family, but there is a sufficient similarity in their food habits to warrant our considering them here. They are closely allied to the famous Mocking Bird of the south, and their musical powers are not very much inferior to that splendid songster. They do not, however, so frequently exercise their power of mimicry. The peculiar mewling note uttered by the Catbird has caused a certain amount of prejudice to exist against it, and has made it subject to persecution at the hands of most boys; but apart from the unpleasant note, the Catbird is one of the most accomplished musicians we have, and it is more to be admired because it does not retire into solitude to pour out its joyous songs, but rather seeks the society of mankind, and in the morning and evening will sing its clear notes from the top of some tree in close proximity to the dwelling house. Its food in the early part of the season consists almost entirely of caterpillars and beetles, which it obtains generally from the branches and leaves of trees, though sometimes after rain it seeks for cut worms and other grubs from the ground. Later in the year it feeds largely upon elderberries and other small wild

fruits, and does occasionally levy some slight toll from the garden; but for all the cultivated fruit it takes it has amply repaid the gardener by its efforts in the destruction of the insect tribe.

Brown Thrush or Thrasher. All that I have said of the Catbird applies to this species, but it is not quite so familiar and confiding in its habits. It displays a decided preference for thick shrubbery at some little distance from the house. Here it remains in seclusion for the greater part of the day, but in the early morning and evening the male bird mounts to the top of some tall tree near its haunt, and for an hour or so will sing his beautiful song, which is much louder, though less varied, than that of the Catbird.

THRASHERS AND MOCKERS.

DESCRIPTION.

CATBIRD.

Crown and tail black; rest of the plumage dark slaty gray; under tail coverts rich chestnut.

L., 8.95; W., 3.75; T., 4.00.

Nest, in thick bushes; sometimes in a brush pile. Eggs, four or five, dark greenish blue.

BROWN THRUSH—THRASHER.

Upper parts rich rufous brown; wing coverts tipped with whitish; under parts white heavily streaked with black except on throat and belly.

L., 11.25; W., 4.00; T., 5.25.

Nest, usually on or near the ground in a low bush. Eggs, four or five, greenish white, thickly speckled with minute dots of reddish brown.

WRENS.

This is a most interesting and useful family of very small birds. Four species of them are found in this Province in the summer. Two of them, the Long-billed Marsh Wren, and the Short-billed Marsh Wren, as their name implies, frequent our marshes and low swampy meadows, where they assist in keeping down hordes of mosquitos that are bred in such places. The Winter Wren is a more transitory visitor, the great bulk of them only passing through here in the spring and fall migrations. A few, however, remain here through the summer, and nest in some secluded ravine in the woods.

The pert little House Wren takes up its abode right in and around the farm buildings, and even in our cities it will find a resting place, if it can get access to sufficient garden room to give it a hunting ground, and as it is quite satisfied to place its nest in a crevice or hole at no great height from the ground, it is not so likely to be dis-



House Wren.

possessed of its home by the European House Sparrow as are birds that prefer a higher location. They are most indefatigable insect hunters, and should be encouraged to build in every garden. All that is necessary is to furnish them with a small box having a hole about one and one-half inches in diameter. Nail this up to a fence, about eight or ten feet from the ground, so that cats cannot get at it; and if any Wrens come that way in the spring they are almost sure to take possession of it, and having once occupied it, they will in all probability return every year. The domestic cat is their worst enemy, and they seem to know it, for as soon as they catch sight of one of these detested creatures they start such a scolding that they arouse the whole feathered tribe in their neighborhood. In the autumn they eat a few elderberries, but this is the only vegetable food I have known them to take.

The number of times House Wrens feed their young in the course of a day has several times been carefully noted. In one case it was found that the young were fed from thirty to forty times every hour, and it must be remembered that the old birds usually carry to their young on each visit not one insect only, but a beak full.

WRENS.

DESCRIPTION.

LONG-BILLED MARSH WREN.

Crown, brown; a white line over eye; back black, streaked with white; rump cinnamon brown; wings and tail barred with blackish; under parts white.

L., 4.75; W., 1.85; T., 1.75.

Nest, globular, attached to flags or rushes in a marsh. Eggs, five or six, pale brownish grey so thickly speckled with minute chocolate dots as to appear almost entirely of that colour.

SHORT-BILLED MARSH WREN.

Dark brown above, everywhere streaked with black, white, and buffy; wings and tail barred; under parts white, washed on the breast, sides and under tail coverts with buffy.

L., 4.25; W., 1.75; T., 1.50.

Nest, globular, in tall grass in low meadows. Eggs; five or six, white.

WINTER WREN.

Above dark brown: wings and tail barred; a whitish superciliary line; under parts pale brown, the lower breast, sides and belly, more or less heavily barred with blackish.

L., 4.00; W., 2.00 T., 1.25.

Nest, usually globular among the roots of a fallen tree, or a brush heap. Eggs, five or six creamy white, spotted with reddish brown.

HOUSE WREN.

Upper parts brown, brighter on rump and tail; back with fine indistinct bars; wings and tail finely barred; sides and flanks with many dark bars, other under parts whitish.

Nest, in a hole or crevice, commonly in a bird box. Eggs, six to eight, white, thickly speckled with reddish brown.

CUCKOOS.

Cuckoos. These birds do not seem to be very well known in our Province, though we have two species, one of which is not common. They are known as the Black-billed Cuckoo and Yellow-billed Cuckoo. Both of them are slim birds, about twelve inches in length, of an olive-brown color above, and white beneath. The Yellow-billed may be distinguished from its relative by the light chestnut color of the inner webs of part of the wing feathers. This is quite noticeable when the bird is flying. It also has the under mandible of the beak clear yellow. In the Black-billed species, the beak is all black, sometimes showing slight dull yellow marks below. Although the birds themselves are not known, most residents of the country must have noticed the loud harsh notes of "kow, kow" uttered by them, most frequently heard before and during rain, by reason of which the birds are in some localities called "rain crows."

The well known Cuckoo of Europe has the bad habit of laying its eggs in the nests of other birds, but although I have heard our birds charged with the same thing, I have never yet come across an instance of it, but have always found their nesting habits to be quite orthodox, though the nest they build can hardly be considered a model of bird architecture.

These two species of birds are the only ones that to my knowledge habitually eat hairy caterpillars, and of these noxious insects they must destroy a large quantity, an examination of their stomachs generally showing a considerable number of them. On one occasion I found the stomach of a Black-billed Cuckoo packed with the spiny caterpillar of *Vanessa antiopa*, an insect that feeds in colonies and does much damage to the elm and willow trees. And as many as two hundred and fifty tent caterpillars have been found in the stomach of a Cuckoo.

The habits of the two Cuckoos are much alike; the only difference I have noticed is that the Yellow-billed species seems to prefer the upper branches of tall trees in which to obtain its food, while the Black-billed resorts more to orchard trees and shrubbery. I have not found any evidence of habitual fruit-eating against either of them, so that from an economic standpoint they must be considered as purely beneficial, even if they do occasionally deposit an egg in the nest of another bird.

As an illustration of the number of caterpillars devoured by these Cuckoos; Chapman says that a Yellow-billed Cuckoo shot by him at



Chrysomitris

six o'clock one morning, had the partially digested remains of forty-three tent caterpillars in its stomach.

An examination of the stomachs of sixteen Black-billed Cuckoos by the Biological survey of the Department of Agriculture at Washington showed the remains of three hundred and twenty eight caterpillars, eleven beetles, fifteen grasshoppers, sixty three saw-flies, three stink bugs, and four spiders. In all probability more individuals than these were represented but their remains were too badly broken for recognition. Most of the caterpillars were hairy and many of them belonged to a genus that lives in colonies and feeds on the leaves of trees, including the apple. One stomach was filled with larvæ of a caterpillar belonging to the same genus as the tent caterpillar and possibly to that species. Other larvæ were those of large moths for which this bird seems to have a special fondness. The beetles were for the most part Click beetles (the larvæ of which are wireworms) and weevils with a few June beetles and some others.

Of the Yellow-billed Cuckoo twenty one stomachs were examined. The contents consisted of three hundred and fifty-five caterpillars, eighteen beetles, twenty-three grasshoppers, thirty-one saw-flies, fourteen bugs, six flies, and twelve spiders. As in the case of the Black-billed Cuckoo most of the caterpillars belong to hairy species and many of them were of large size. One stomach contained twelve American tent caterpillars; another, two hundred and seventeen fall web-worms. The beetles were distributed among several families but all more or less harmful to agriculture. In the same stomach which contained the tent caterpillars were two Colorado potato beetles. The saw-flies were in the larval stage in which they resemble caterpillars very closely. Many species of saw-fly larvæ are exceedingly injurious, among them being the well known currant worm.

At midsummer the Yellow-billed Cuckoo seems to be much more active at night than during the day. In the trees around my house I commonly hear them as they forage for food at all hours from sunset to dawn.

CUCKOOS.

DESCRIPTION.

BLACK-BILLED CUCKOO.

Upper parts clear olive brown, with a greenish gloss, wings and tail the same the latter tipped with white. Under parts dull white; in the adult the eyelids scarlet; yellow in birds of the first season; no rufous on the wings; bill blackish except an occasional trace of yellow on lower mandible.

L., 11.75; W., 5.50; T., 6.50.

Nest, in bushes or low trees. Eggs, two to five, pale greenish blue.

YELLOW-BILLED CUCKOO.

Upper parts clear olive brown, with a greenish gloss; wings mostly reddish chestnut on inner webs of the quills; central tail feathers like the back, the rest black with large white blotches at tips, the outer feathers margined with white; lower mandible chiefly yellow.

L., 12.00; W., 5.50; T., 6.50.

Nest, in bushes or low trees. Eggs, four or five, pale greenish blue.

VIREOS.

Vireos. Among the most voracious, and therefore the most useful, of our insect-eating birds are the Vireos, or Greenlets as they are sometimes called. The family contains six species, of which the Red-eyed Vireo, Philadelphia Vireo, and Warbling Vireo are fairly common summer residents, breeding in our orchards and shrubberies throughout their range in the Province. The Yellow-throated Vireo is uncommon, but probably breeds where it occurs. The White-eyed Vireo is a southern form which has been recorded only once in Ontario, and the Blue-headed Vireo is a regular and not uncommon migrant in spring and autumn, probably breeding in the interior. All these Vireos glean their insect food from the trees and shrubs, never descending to the ground in search of it, and their appetite seems to be insatiable; even in the hottest weather when most birds retire to the shade and rest for a time in the middle of the day, these birds are active and constantly feeding.

All insect-eating birds require about their own weight of insect food every day, but if I may judge from my experience in trying to feed some of them in captivity, the Vireos require much more than that. Probably the wear and tear caused by their constant activity compels them to consume more than most other birds of their size. These birds and the Flycatchers, like the Hawks and Owls, and some others, have the habit of disgorging pellets composed of the indigestible portions of their food.

VIREOS.

DESCRIPTION.

Crown slaty gray, edged with blackish line, a conspicuous white line over eye; below this a dusky stripe through eye; rest of the upper parts light olive green; no wing bars. Under parts white faintly shaded along sides and on lower tail coverts with olive; eyes red. No spurious quill.

L., 6.20; W., 3.20; T., 2.20.

Nest, in bushes or trees, pensile, suspended from a forked branch. Eggs, four or five, white, with a few brown or blackish spots about the larger end.

PHILADELPHIA VIREO.

Upper parts olive green brightest behind; crown sometimes grayish; a dull white line over the eye; wings and tail edged with olive green; under parts pale yellowish; nearly white on throat and belly. No obvious wing bars; no spurious quill.

L., 4.75; W., 2.60; T., 2.00.

Nest, pensile, suspended from a forked branch of a tree or bush. Eggs, four, similar to those of the Red-eyed Vireos.

WARBLING VIREO.

Upper parts, ashy olive green, wings and tail brownish edged with olive green; first primary very short not more than 1.00; under parts white more or less washed with yellowish. No wing bars.

L., 5.75; W., 2.85; T., 2.20.

Nest, pensile, suspended from the forked branch of a tree. Eggs, three or four, white, with a few spots of brown or blackish at the larger end.

YELLOW-THROATED VIREOS.

Upper parts bright olive green, changing to gray on the rump and upper tail coverts; greater and middle wing coverts tipped with white, forming two distinct wing bars; outer web of inner secondaries white; below bright yellow; belly and under tail coverts white; superciliary line and ring round eye yellow; tail dusky, nearly all the feathers with white edging; no spurious quills.

L., 6.00; W., 3.00; T., 2.25.

Nest, pensile, suspended from a fork in a bush or low tree. Eggs, four or five, white, with a few spots of dark brown or blackish chiefly at the larger end.

WHITE-EYED VIREOS.

Upper parts bright olive green, more or less washed with grayish; greater and middle wing coverts tipped with yellowish white, forming two distinct wing bars; outer web of inner secondaries whitish; lores and eye ring yellow; throat white or whitish; belly white; breast and sides washed with greenish yellow; iris white in adult; hazel in the young.

L., 5.27; W., 2.37; T., 2.00.

Nest, pensile, suspended from a forked branch in a bush or low tree. Eggs, three or four, white, with a few specks of black or dark brown at the larger end.

BLUE-HEADED VIREOS.

Crown and sides of head, bluish gray; back olive green; wings and tail dusky, most of the feathers edged with whitish; greater and middle wing coverts tipped with white forming two distinct wing bars; a broad white line from nostrils around the eye and a dusky loreal line. Below, white, sides washed with greenish yellow.

L., 5.50; W., 2.75; T., 2.25.

Nest, pensive, suspended from a fork of a bush or low tree. Eggs, four or five, white, with a few spots of blackish or dark brown chiefly at the larger end.

WAXWINGS.

We have two species of this family in Canada. The Bohemian Waxwing is a winter visitor only, and a somewhat rare one. As it is of no economic importance whatever it need not be considered.

The Cedar Waxwing or cherry bird is very common and, though very beautiful and an insect destroyer to a certain extent, its value to the fruit grower is somewhat questionable. It undoubtedly consumes a large number of cherries and currants, and some few raspberries, but so far as I have observed the mischief it does is confined to these varieties of fruit alone.

The quantity of fruit consumed by each individual Waxwing does not amount to much, but the trouble is that these birds are gregarious at all times, and visit the cherry orchards in such large flocks, and remain where they find food to their liking so long, that they really do seriously reduce the value of a crop. Where a man makes a speciality of growing these small fruits, and finds himself visited by an excessive number of Cherry birds he is undoubtedly justified in protecting his property from destruction, which does not necessarily mean killing the birds. As against this cherry eating habit of the Waxwing, it may be urged that the birds destroy a large number of injurious insects, leaf-eating beetles especially forming a large proportion of their food. They are also very expert fly-catchers, often hawking about after winged insects in the manner of the Swallows, though their flight is never long sustained. At other times they dart out after passing insects in the manner of the flycatchers, and so on the whole may be said to do more good than harm, for it is only when too many have gathered together in some particular cherry orchard that the damage they do is noticeable at all.

The Cedar Waxwing is rather erratic in its movements, generally being with us a summer resident only, but I have occasionally seen large numbers here in the winter. They then feed on the berries of the Mountain Ash, haws and such other wild fruits as remain hanging on the bushes during the cold season.



Cedar Waxwing.

WAXWINGS.

DESCRIPTION.

BOHEMIAN WAXWING.

Forehead, chin and line through eye velvety black; a conspicuous crest; front of crown chestnut brown; upper parts rich grayish brown; upper tail coverts, wings and tail grayish; primary coverts and secondaries tipped with white, the latter with narrow red, sealing-wax like tips (sometimes wanting); all but the outer primaries tipped with yellow or white on the outer web; tail broadly tipped with yellow; breast grayish brown; under tail coverts, rich chestnut.

L., 8.00; W., 4.60; T., 2.60.

Nest, in trees. Eggs, pale blue, spotted and marked with purplish brown or black.

CEDAR WAXWING.

Forehead, chin and line through the eye velvety black, bordered on the forehead with white; a conspicuous crest; upper parts rich grayish brown; upper tail coverts, wings and tail gray; secondaries and sometimes tail with, small narrow, red sealing wax like tips (these may be entirely absent); tail tipped with yellow; breast grayish brown, yellowish below; under tail coverts white.

L., 7.25; W., 2.50; T., 2.40.

Nest, in a low tree. Eggs, four or five, pale blue, spotted and marked with purplish brown or black.

FLYCATCHERS.

These birds, as their name implies, subsist largely upon winged insects, which they capture by darting upon them from some elevated post overlooking an open space frequented by their prey. We have eight species, of which the Crested Flycatcher, the Kingbird, the Phoebe bird, the Wood Pewee, and the Least Flycatcher are summer residents, and the Olive-sided, Yellow-bellied, and Traill's Flycatcher are transient visitors, passing through southern Ontario in their spring and fall migrations, and breeding in the interior.

The Kingbird is probably the most obtrusive creature of the whole feathered tribe in Canada. As soon as a pair take possession of a tree in an orchard they immediately proclaim the fact to the neighborhood, and then trouble befalls everything wearing feathers that ventures to trespass on what they are pleased to consider their domain. Crows, Hawks, Jays, and Blackbirds are their especial detestation, and should one of these birds appear near their tree, an attack by the Kingbirds immediately follows, the assault being kept up until the intruder is ignominiously driven off, having lost a few feath-

ers in the encounter, the loss serving to remind him that others have rights which he is bound to respect. The Kingbird captures a vast number of mature insects, both in the air and on the ground, and as at least half these insects would produce eggs to become caterpillars the service rendered is very great. In the early spring, when driven by hunger, the Kingbird will eat the berries of the sumach, but as the clusters of these berries form a favorite hibernating place for many beetles, it is quite possible that the insects form the attraction and not the fruit. I have heard complaints from bee-keepers that these birds will destroy bees. It is just possible that they will occasionally take them, but I have seen no evidence that they have acquired the habit. In case the Kingbirds should be seen frequenting the vicinity of hives it would be well to watch closely before shooting the birds, as they are too valuable to be wantonly destroyed, and in all cases an examination of the stomach contents should be made, and the information gained should be reported.

Since writing the above I have received a number of reports from gentlemen in various parts of the Province, who are engaged in bee-keeping, and who have therefore had occasion to observe somewhat closely the habits of such birds as might be suspected of injuring their bees. In no case has the Kingbird been found to be injurious to the inhabitants of the hives, and in all cases the writers speak highly of the services rendered by the Kingbirds in destroying injurious insects and driving away Crows and Hawks.

Mr. Thaddeus Smith, of Pelee Island, says, "I am a cultivator of the grape and other fruits and also a bee-keeper. . . . I was raised in one of the Southern States, and never knew the Kingbird there by any other name than 'Bee Martin,' and of course it was considered a great enemy of the Bees. I have been here over thirty years, and at one time made the science of apiculture a special study, raising choice Italian queens, etc. Kingbirds are here every season, and are to be seen around my bee hives. Years ago I killed some and examined their stomachs, and found them full of bees, but nearly every bee in them was a *drone*; I found *only one worker bee*. You know the drones have no sting and as their name implies they are of no use in the hive. They are the male bee, and their only use is to fertilize the queen bee. The only damage the Kingbird can do is that they might sometimes catch the young queen while on her wedding flight as her size and slow flight make her quite conspicuous. But the possibility of this happening is so slight that I never now shoot the King birds."

The United States Biological Survey has made an examination of 281 stomachs of King birds collected in various parts of the country, but found only fourteen containing remains of honey bees. In these fourteen stomachs there were in all fifty honey bees of which forty were drones. Four were certainly workers and the remaining six were too badly broken to be identified as to sex.

One bee raiser in Iowa, suspecting the Kingbirds of feeding upon his bees, shot a number near his hives, but when the birds' stomachs



Kingbird.

were examined by an expert entomologist not a trace of honey bees could be found. (F.E.L., Beal B.S.)

This coincides with my own experience during the last thirty years, during which time I have examined a great many Kingbirds, but have never yet found honey bees among the insects eaten by them.

Phæbe. There is scarcely a farm in the country that has not one or more pairs of Phæbe birds nesting in or about the buildings, and I fancy there are not many bridges of any size under which a nest may not be found; and so I hope it may continue for the Phæbe is a most useful and friendly little bird. It has all the good traits of the family without being too aggressive, and no suspicion of any act which is in the least injurious attaches to it. If the birds and their nests are left unmolested, they will return year after year to their old home, and as none of our feathered friends are more valuable than they, we should give them every encouragement to do so.

I have particularly mentioned the Kingbird and the Phæbe because they may be regarded as typical of the whole family to which they belong, and being familiar in their habits, they are likely to be well known to everyone. All the other species are more or less birds of the woods and orchards, but each one of them in its own chosen locality is rendering us good service the whole summer through.

FLYCATCHERS.

DESCRIPTION.

KINGBIRD.

Upper parts grayish slate colour darker on the head and upper tail coverts; crown with a concealed orange patch; tail black, tipped with white; under parts white washed with grayish on the breast; wings dusky with much whitish edging.

L., 8.50; W., 4.60; T., 3.50.

Nest, usually on the horizontal branch of a low tree. Eggs, four or five, white, spotted with reddish brown and lilac.

CRESTED FLYCATCHER.

Upper parts grayish brown, tinged with olive; outer vane of primaries margined with pale chestnut; inner vane of all but the middle tail feathers pale chestnut; throat and breast pearly gray; belly sulphur yellow.

L., 9.00; W., 4.15; T., 3.75.

Nest, in a hole in a tree. Eggs, four or five, white streaked lengthwise with purplish brown and chocolate.

PHŒBE.

Upper parts dark grayish brown; crown much darker; wings and tail dusky, outer tail feather, inner secondaries and usually the wing coverts, edged with whitish; under parts white tinged with brownish gray across the breast and elsewhere washed with yellowish. In the autumn the lower parts are often decidedly yellow.

L., 7.00; W., 3.33; T., 3.25.

Nest, on a beam or rafter of a building. Eggs, four or five usually pure white.

OLIVE-SIDED FLYCATCHER.

Upper parts dusky brown with an olive tinge; darker on the crown; wings and tail dusky; chin, throat, under tail coverts and centre line of the breast, white slightly tinged with yellowish; rest of under parts grayish brown. A tuft of fluffy yellowish white feathers on either flank.

L., 7.40; W., 4.05; T., 2.70.

Nest, on a horizontal branch of a tree. Eggs, four or five, creamy white, spotted with reddish brown.

WOOD PEWEE.

Upper parts olivaceous brown, rather darker on the head, wings and tail dusky; wing coverts tipped with whitish forming two more or less distinct wing bars; under parts white washed with olive gray on sides of throat and breast.

L., 6.50; W., 3.33; T., 2.60.

Nest, on a low tree. Eggs, four or five, white dotted and marked at larger end with various shades of brown.

YELLOW-BELLIED FLYCATCHER.

Upper parts olive green; wings and tail dusky; greater and lesser wing coverts tipped with white; under parts sulphur yellow, the throat, breast and sides more or less washed with olive green.

L., 5.65; W., 2.65; T., 2.16.

Nest, on the ground. Eggs, four or five, creamy white, spotted and blotched with brown of various shades.

TRAILL'S FLYCATCHER.

Upper parts olive green, with a brownish tinge; wings and tail dusky; greater and lesser wing coverts tipped with tawny white; under parts whitish washed with dusky gray on the breast and sides; a slight tinge of yellowish below.

L., 6.09; W., 2.87; T., 2.33.

Nest, low down in a bush. Eggs, four or five, creamy white, with reddish brown markings chiefly towards the larger end.



Phoebe.

LEAST FLYCATCHER.

Upper parts grayish olive; wings and tail dusky; greater and lesser wing coverts tipped with ashy brown; under parts whitish, washed with dusky grayish on the breast and sides; pale yellowish below.

L., 5.40; W., 2.50; T., 2.20.

Nest, in a crotch of a tree. Eggs, four or five usually pure white.

SWALLOWS.

Of this family we have five species, viz: the Purple Martin, the Barn Swallow, Cliff Swallow, White-breasted Swallow, and Sand Martin, all regular summer residents. Another one, the Rough-winged Swallow, occasionally occurs here, but as it closely resembles the Sand Martin its appearance is not readily noticed.

The economic importance of these birds is very great: without them the smaller winged insects would multiply to such an extent as to become an unbearable nuisance to men and animals: for it is, I believe, to these birds chiefly that we are indebted for our freedom in the clearing and cultivated parts of the country from the swarms of midges, black flies, and gnats of various kinds that so abound in the woods.

These birds seem to have a great predilection for the society of men, partly because the clearing he makes in a forest country opens up to them the necessary space for feeding grounds, and partly because the buildings he erects afford them convenient nesting places of which the House Sparrow, unfortunately, is dispossessing them.

Except in very stormy weather the Swallows usually capture their food whilst they are on the wing, but in the cold windy days that frequently occur in early spring the insects on which they depend are too chilled to fly, and then the Swallows seek them in open places on the ground. The sandy shores of our lakes are particularly resorted to at such times.

In the latter part of July and the beginning of August the large female ants swarm from their nests, each one prepared to found a colony for herself were she permitted; the Swallows, fortunately for us, however, interfere and gorge themselves upon these creatures, the Purple Martins particularly destroying vast numbers of them, even after the ants have divested themselves of their wings; when this has taken place the Martins alight on the ground, pursuing them there with the greatest activity.

None of the Swallows, Swifts, or Night Hawks ever under any circumstances take any vegetable food while in this Province, nor have they any habits that are open to objection of any kind, so that our utmost efforts should be put forth to preserve them and encourage them to build about our premises.

I have heard one or two people state that they did not like Swallows about their houses because they brought bed bugs; how such an

idea got into any person's head is difficult to understand, and let me say most emphatically that there is no foundation for the belief whatever. Swallows, like all other living creatures, have their insect parasites, but no parasite affecting the Swallows will ever trouble human beings.

SWALLOWS.

DESCRIPTION.

PURPLE MARTIN.

Adult male. Glossy blue black; wings and tail duller.

Adult female and immature. Upper parts glossy bluish black, duller than in the male; wings and tail dusky black; throat, breast and sides brownish gray, more or less tipped with white; belly white.

L., 8.00; W., 5.80; T., 3.00.

Nest, in holes in buildings or in bird houses. Eggs, four or five white.

CLIFF SWALLOW.

Forehead creamy white, crown steel blue; throat and sides of the head chestnut; a brownish gray ring round the neck; breast brownish gray, tinged with rufous and with a steel blue patch in its centre; belly white; back steel blue; upper tail coverts, pale rufous; tail dusky.

L., 6.00; W., 4.35; T., 2.00.

Nest, of mud generally flask shaped, beneath the eaves of buildings, or under cliffs. Eggs, four or five spotted with reddish brown.

BARN SWALLOW.

Upper parts, glossy steel blue; tail deeply forked, all but the middle feathers with white spots on their inner webs. Forehead throat and upper breast rich chestnut; lower parts same colour but paler.

L., 7.00; W., 4.70; T., 3.30.

Nest, generally on or against a rafter in a building. Eggs, four or five, white, spotted with reddish brown.

WHITE-BREASTED SWALLOW.

Upper parts glossy greenish blue; under parts pure white.

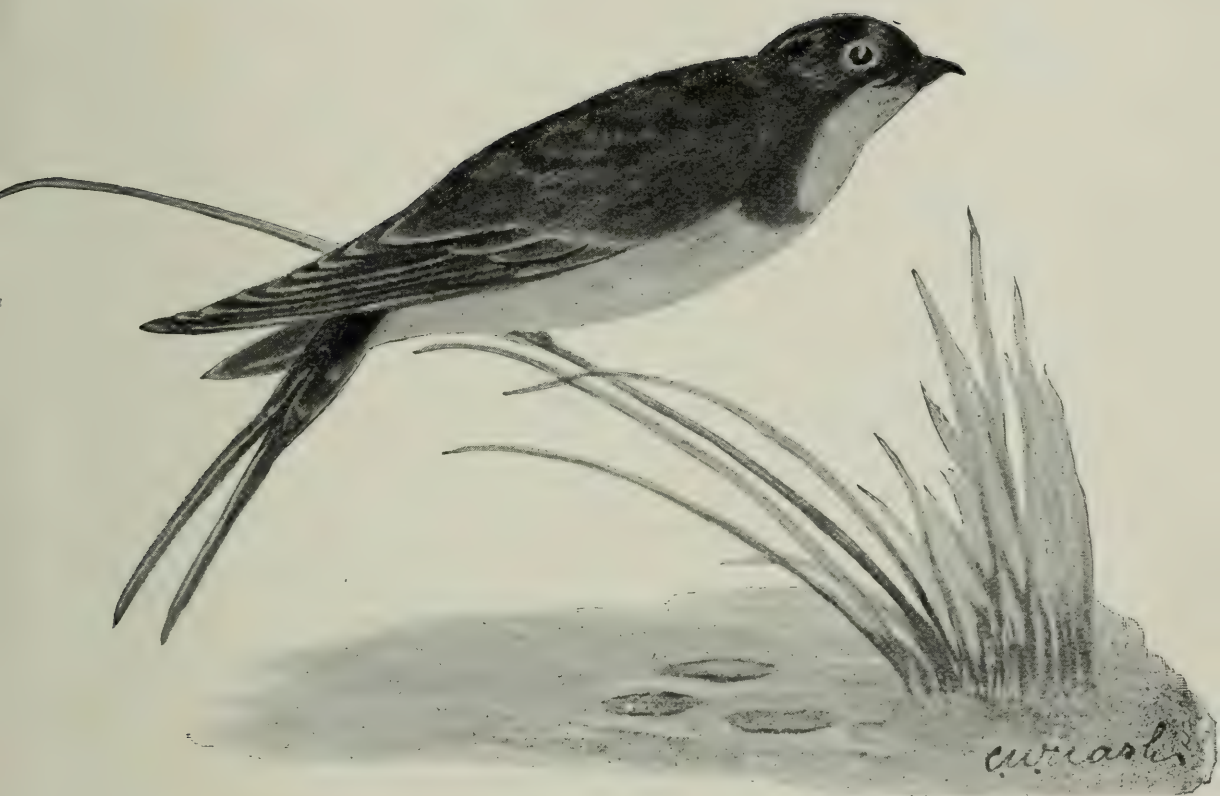
Immature. Upper parts brownish gray; below white.

L., 6.00; W., 4.75; T., 2.50.

Nest, in a hole in a tree or building. Eggs, five or six, white.

SAND MARTIN—BANK SWALLOW.

Upper parts brownish gray; throat white; a brownish gray band on the breast. A small tuft of feathers above hind toe.



Barn Swallow.



Nighthawk.



Whip-poor-will.

L., 5.20; W., 4.00; T., 2.00.

Nest, in a hole in a sand bank; these birds usually nest in colonies. Eggs, four to six, white.

ROUGH-WINGED SWALLOW.

Upper parts brownish gray; throat and breast pale brownish gray; belly white; outer web of first primary with a series of recurved hooklets; no tuft of feathers above the hind toe.

L., 5.75; W., 4.35; T., 2.10.

Nest, usually in holes under bridges, or in sand banks. Eggs, four to six, white.

NIGHTHAWKS.

All the Swallow tribe gather their food during the day, and the hotter and brighter it is the more active they seem to be; the Chimney Swift's period of greatest activity is the early morning and late evening. The Night Hawk and Whip-poor-will commence their work at dusk and keep it up till sunrise. Their food consists, for the most part, of the large night-flying moths and beetles. On one occasion, however, I found the stomach of a Whip-poor-will filled with the large female wingless ants, which could only have been obtained from the ground, and in all probability in the day time. The common June bug is a favorite article of food with both these birds, and as this is a very destructive insect, both in its larval and mature stages, the birds are entitled to our best consideration for the good work they do in lessening its numbers.

Since writing the above I have found that the large black ant referred to, is active at night as well as through the day and therefore the Whip-poor-will probably captured them during its ordinary feeding time. Where these insects occur abundantly they become an intolerable nuisance, working their way into houses, they swarm over provisions of all kinds and render them distasteful. They also have a habit of forming their nests under the shingles of a roof and when they do so, leakages quickly follow and repairs are constantly required. When established in a roof it is almost impossible to dislodge them without tearing out the whole fabric. Any bird that assists in keeping these ants in check will always be considered a benefactor by those who have suffered from their ravages.

NIGHTHAWKS.

DESCRIPTION.

WHIP-POOR-WILL.

Adult male. Upper parts dark brownish gray, streaked and mottled with brownish-black and buffy; primaries dusky black, spotted in bars with rufous bars; four middle tail feathers, like those of the back, the three lateral ones white in their terminal half;

throat and breast, similar to the back, with a transverse band of white on the foreneck; rest of the lower parts paler than above and mottled, or barred with blackish.

Adult female.—Similar but three outer feathers narrowly tipped with pale buff and band on the throat creamy buff, instead of white.

L., 9.75; W., 6.08; T., 4.65.

Nest, none. Eggs, two, creamy white, much blotched and marbled with various shades of brown and lilac. The eggs are deposited on the ground, among ferns and dead leaves, in woods or thickets.

NIGHTHAWK.

Adult male. Upper parts mottled with black, brown gray and tawny; below from the breast barred with dusky black and white; throat with a broad white band; primaries dusky, crossed in the middle by a conspicuous white bar; tail dusky black, with broken bars of buff and a large white spot on all the feathers near the end, except the middle ones.

Female. Similar, but no white band on tail and throat patch buff instead of white.

L., 10.00; W., 7.85; T., 4.60.

Eggs, two, deposited on the bare ground, in open fields or pastures, sometimes in cities on a flat gravelled roof, grayish white marbled and speckled with various shades of gray and brown.

WARBLERS.

Warblers. This family contains a large number of species, among them being some of our brightest colored and most interesting birds, though none of them are remarkable as songsters. They are all entirely insectivorous, and consequently of great value from an economic point of view. Thirty-three species are known to occur in this Province; of these seven are so rare as to be considered accidental visitors. They are the Prothonotary, the Golden-winged and Hooded Warblers, the Louisiana Water Thrush, the Prairie Warbler, Kirtland's Warbler, and the Yellow-breasted Chat. Probably when they do occur, they remain and breed here. The Cape May, Orange-Crowned, Tennessee, Cerulean, and Connecticut are regular but uncommon visitors. Of these the Cerulean is known to breed in some localities in southern Ontario, but it is not generally distributed.

The Parula, Black-throated blue, Myrtle, Magnolia, Blackburnian, Bay-breasted, Black poll, Palm and Wilson's Warblers all pass on to the north before nesting. Just how far they go is difficult to say, but in all probability the majority of them at any rate will be found breeding in the unsettled districts of Muskoka, Algoma, etc., and some even south of that.

The Black and white, Nashville, Yellow, Chestnut-sided, Pine, Redstart, Black-throated green, Oven bird, Water Thrush, Mourning, Maryland, and Canadian Warblers, are generally distributed



Yellow Warbler.



American Redstart.

and breed with us in suitable localities and in varying numbers each season, the most familiar of them all being the Yellow Warbler, which habitually raises its young in and about our orchards and shrubberies. All through the summer they are actively engaged in exterminating the hosts of our smaller insect enemies, and many thousands of broods of caterpillars are destroyed by them before they have become large enough to do mischief.

WARBLERS.

DESCRIPTION.

BLACK AND WHITE WARBLER.

Adult male. No yellow anywhere; upper parts streaked with black and white; ear coverts black inner webs of outer tail feathers with white patches; wing coverts black tipped with white; throat and upper breast black; sides streaked with black and white; middle of belly white.

Adult female. Similar, with fewer black streaks; sides washed with brownish.

Immature. Similar to female but more streaked below.

L., 5.30; W., 2.75; T., 2.00.

Nest, on the ground at base of a stump. Eggs, four or five, white, spotted with reddish or dark brown, chiefly in a wreath at larger end.

PROTHONOTARY WARBLER.

Adult male. Whole head neck and under parts rich orange, lighter on the belly; back greenish yellow, changing to bluish gray on the rump; wings and tail ashy; inner webs of all but the middle feathers white, except at the tip. No wing bars.

Adult female. Similar, but the yellow is paler, the belly with more white.

L., 5.50; W., 2.90; T., 1.85.

Nest, in a hole in a stump. Eggs, four or five, white, thickly and rather heavily marked and washed with various shades of brown.

GOLDEN-WINGED WARBLER.

Adult male. Crown bright yellow; rest of the upper parts bluish gray, sometimes washed with greenish; a large black patch about the eye; separated from another on the throat by a white stripe; a white line over the eye, wings and tail bluish gray; tips of middle wing coverts and outer webs of greater ones, bright yellow, forming a large yellow patch on the wing; outer three tail feathers with large white patches on their inner webs at the tip fourth feather with a smaller patch; lower breast and belly white; sides grayish.

Adult female. Similar, but the crown duller, the patch on the sides of the head and throat grayish instead of black.

L., 5.10; W., 2.45; T., 1.95.

Nest, on or near the ground, generally in bushy fields. Eggs, four or five, white, speckled and spotted with various shades of brown, chiefly about the larger end.

NASHVILLE WARBLER.

Adult. Top and sides of the head bluish gray, a partially concealed chestnut patch in the centre of the crown; back and rump bright olive green wings and tail edged with the same; under parts bright yellow, whiter on the belly.

L., 4.75; W., 2.30; T., 1.80.

Nest, on the ground among bushes. Eggs, four or five, white, thickly speckled with reddish brown, chiefly at the larger end.

ORANGE-CROWNED WARBLER.

Adult. Upper parts ashy olive green; feathers of the crown orange at the base; wings and tail edged with olive green; eye ring yellow; under parts greenish yellow, obscurely streaked with dusky on the breast.

Immature. Similar, but duller and without orange on the crown.

L., 5.00; W., 2.50; T., 2.00.

Nest, on or near the ground. Eggs, four or five, white, speckled with various shades of brown, chiefly at the larger end.

TENNESSEE WARBLER.

Adult male. Top and sides of the head bluish gray, in strong contrast with the bright olive green back and rump; wings and tail edged with olive green; inner margin of inner vane of outer tail feathers generally white at tip; under parts white.

Adult female. Similar, but crown tinged with greenish and under parts washed with yellowish.

Immature. Upper parts uniform olive green under parts washed with yellowish; under tail coverts white.

L., 5.00; W., 2.65; T., 1.70.

Nest, in a low bush near the ground. Eggs, pearly white, with a wreath of brown and purplish spots around the larger end.

PARULA WARBLER.

Adult male. Upper parts blue; a brownish yellow patch in the middle of the back; greater and lesser wing coverts tipped with white; outer tail feathers with a white patch near the end; throat and breast yellow, more or less marked with rufous a rich brown or blackish band across the breast belly white.

Adult female. Similar, but duller and the throat and back patches indistinct or wanting.

L., 4.75; W., 2.40; T., 1.75.

Nest, generally among hanging mosses. Eggs, four or five, white, with reddish brown spots, chiefly around the larger end.

CAPE MAY WARBLER.

Adult male. Crown black, slightly tipped with greenish; ear coverts chestnut, bounded behind by a large yellow patch on the side of the neck; back olive green, broadly streaked with black; rump yellow; a large white patch on the wing coverts; outer tail feathers with a large white patch on their inner webs, near the tip; under parts yellow, heavily streaked with black, lower belly and under tail coverts whitish.

Adult female. Upper parts grayish olive green; rump yellowish; a yellow line over the eye; middle wing coverts with narrow white tips; outer tail feathers with a white patch on their inner webs near the tip; under parts yellow, streaked with black.

L., 5.00; W., 2.60; T., 1.85.

Nest, partially pensile, on a branch of a small tree in open woodland. Eggs, three or four, dull white, slightly speckled and wreathed round the larger end with spots of brown and lilac.

YELLOW WARBLER.

Adult male. Upper parts greenish yellow; bright yellow on crown; wings edged with yellow; tail dusky, the inner vanes of the feathers yellow; under parts bright yellow streaked with reddish.

Adult female. Upper parts uniform yellowish olive green, tail and wings as in the male, under parts yellow, but slightly streaked.

L., 5.25; W., 2.50; T., 2.00.

Nest, in shrubs or low trees. Eggs, four or five, bluish white, spotted and blotched with reddish brown.

BLACK-THROATED BLUE WARBLER.

Adult male. Upper parts slaty blue; wings and tail edged with blue; base of the primaries white, forming a white spot on the wing at the end of the primary coverts; inner vanes of outer tail feathers with a white patch near their tips; sides of the head and throat black; breast and belly white.

Adult female. Upper parts dull olive greenish sometimes with faint bluish shade, the white patch on outer feathers of tail sometimes scarcely distinguishable; white at base of the primaries very much reduced; ear coverts dusky gray; under parts soiled yellowish.

L., 5.25; W., 2.50; T., 2.25.

Nest, in a bush near the ground. Eggs, four or five, white, dotted with various shades of brown, chiefly at the larger end.

MYRTLE WARBLER.

Adult male. A yellow patch on the crown, rump, and either side of the breast; upper parts bluish gray, streaked with black; two white wing bars; outer tail feathers with white spots on their inner vanes near the tip; throat white; breast heavily marked with black; belly white.

Adult female. Similar but duller, the blue with a brownish tinge and less black below.

L., 5.65; W., 2.85; T., 2.25.

Nest, in low trees. Eggs, four or five, grayish white, spotted and speckled with various shades of brown.

MAGNOLIA WARBLER.

Adult male. Crown bluish gray; cheeks and forehead black, a white line behind the eye; back black, bordered with olive green; a large white patch on the wing coverts; rump yellow, tail black, inner vanes of all but the central feathers with white patches on their middle, the end third of the feather being entirely black; throat yellow, breast and sides heavily streaked with black.

Adult female. Similar but with the back greener and the colours duller.

L., 5.12; W., 2.30; T., 2.00.

Nest, in low trees. Eggs, white, marked with dots of varying shades of brown, chiefly wreathed at larger end.

CERULEAN WARBLER.

Adult male. Upper parts bright blue; sides of head and back streaked with black; wings and tail edged with blue; two white wing bars; inner vanes of all but the central tail feathers with white patches at their tips; under parts white, sides and breast streaked with bluish black.

Adult female. Upper parts bluish olive green, wings and tail as in the male; under parts white, more or less tinged with yellowish.

L., 4.50; W., 2.65.

Nest, in a tree. Eggs, four, creamy white, thickly blotched with reddish brown.

CHESTNUT-SIDED WARBLER.

Adult male. Crown bright yellow; a black line behind the eye; front part of the cheeks black; ear coverts white; back streaked with black and margined with olive green; wing bars yellowish white; tail black the outer feathers with white patches on their inner vanes at the tip; under parts white the sides chestnut.

Adult female. Similar but duller in colour.



Myrtle Warbler.

Immature. Upper parts, bright yellowish olive green, back sometimes streaked with black; wing bars yellowish white; under parts pure white, the sides sometimes with spots of chestnut.

L., 5.14; W., 2.45; T., 2.00.

Nest, generally low down in a bush. Eggs, four or five, white, wreathed at the larger end with various shades of brown.

BAY-BREASTED WARBLER.

Adult male. Forehead and cheeks black; a creamy buff patch on the sides of the neck; crown chestnut; throat, upper breast and sides reddish chesnut; back brownish ashy, streaked with black; two white wing bars; inner vanes of outer tail feathers with white patches at their tips, lower breast and belly buffy white.

Adult female. More olivaceous than male and colours duller, but always more or less chestnut.

Immature. Upper parts bright olive green, indistinctly streaked with black; wings and tail much as in the adults; under parts white tinged with buff on sides and flanks.

L., 5.63; W., 2.95; T., 2.12.

Nest, in low trees. Eggs, four or five, white, finely dotted, chiefly at the larger end, with various shades of brown.

BLACK-POLL WARBLER.

Adult male. Crown black; ear coverts white, nape streaked, black and white; back and rump ashy, streaked with black; two white wing bars; inner vanes of outer tail feathers with white patches at their tips; under parts white, streaked with black, the streaks most numerous on the sides and wanting on the middle of the breast and belly.

Adult female. Upper parts olive green, distinctly streaked with black; wings and tail as in the male; under parts white tinged with yellow; the breast and sides streaked with black.

Immature. Similar to female, but the upper parts brighter and not distinctly streaked; under parts yellower and not distinctly streaked.

L., 5.75; W., 3.00; T., 2.25.

Nest, generally in spruce trees. Eggs, four or five, white, more or less speckled and blotched at the larger end with various shades of brown.

BLACKBURNIAN WARBLER.

Adult male. Back, black more or less interrupted with yellowish; crown, with a central orange spot; a broad black stripe through the eye enclosing the orange under eye lid; rest of head with whole throat, most brilliant orange; other under parts, whitish, more or less tinged with yellow; sides streaked with black; wing bars fused into a large white patch; tail blotches, white, occupying nearly all the outer feathers.

Adult female. Upper parts, olive and black streaked superciliary line and throat clear yellow, fading insensibly on the breast; lower eyelid yellow; wing patch, resolved into two bars; tail blotches nearly as extensive as in the male.

L., 5.25; W., 2.75; T., 2.25.

Nest, usually in coniferous trees. Eggs, four, greenish white, speckled towards the larger end with various shades of brown and lilac.

BLACK-THROATED GREEN WARBLER.

Adult male. Upper parts bright olive green, back sometimes spotted with black; line over the eye and cheeks bright yellow, ear coverts dusky; two white wing bars; inner vanes of outer tail feathers entirely white, outer web white at the base; throat and breast black; belly white, sometimes tinged with yellow; sides streaked with black.

L., 5.10; W., 2.45; T., 2.00.

Adult female. Similar, but the black of throat and breast more or less mixed with yellowish.

Nest, generally in coniferous trees. Eggs, four, white, spotted with various shades of brown chiefly at the larger end.

KIRTLAND'S WARBLER.

Head bluish gray, sometimes spotted with black; lores and sides of the throat black; back brownish ashy, spotted with black; no white wing bars; outer tail feathers with white patches on their inner webs at the tips; under parts pale yellow; sides streaked and spotted with black.

L., 5.75; W., 2.75; T., 2.25.

PINE WARBLER.

Adult male. Upper parts bright olive green sometimes washed with ashy; two whitish wing bars; outer tail feathers with white patches on their inner vanes near the tip; under parts bright yellow, more or less washed with ashy, turning to white below, sides sometimes with a few black streaks.

Adult female. Similar, but much duller; under parts mostly whitish tinged with yellow.

L., 5.50; W., 2.75; T., 2.25.

Nest, usually in a pine tree. Eggs, four or five, grayish white, much speckled with various shades of brown, chiefly at the larger end.

PALM WARBLER.

Crown chestnut; back brownish olive; rump olive green; no white wing bars; secondaries sometimes tinged with chestnut; tail edged with olive green the outer feathers, with white spots on their inner vanes

near the tips; line over the eye and eye ring yellow; under parts entirely bright yellow; sides of the throat, breast and sides, streaked with chestnut.

L., 5.45; W., 2.60; T., 2.25.

Nest, on or near the ground. Eggs, four or five, white, spotted with various shades of brown chiefly near the larger end.

PRAIRIE WARBLER.

Adult male. Upper parts bright olive green; back spotted with chestnut; wing bars yellowish; outer tail feathers with large white patches at their tips, the outer vane of the outer feather white at the base; a yellow line over the eye; lores and a crescent below the eye black; under parts bright yellow; sides heavily streaked with black.

Adult female. Similar, duller, and sometimes with no chestnut on back.

Nest, in briary bushes. Eggs, four or five, white, spotted with various shades of brown, chiefly in a wreath at the larger end.

GOLDEN-CROWNED THRUSH—OVEN-BIRD.

Centre of crown, orange brown, bordered with two black stripes; rest of the upper parts, wings and tail olive green; no wing bars or tail patches; under parts white, thickly spotted with dusky on breast and sides; a narrow blackish maxillary line; eye ring white.

L., 6.15; W., 3.00; T., 2.25.

Nest, on the ground, covered in, the entrance at one side. Eggs, four or five, white, speckled finely with reddish brown and lilac.

WATER THRUSH.

Upper parts and tail deep olivaceous brown; no wing bars or tail patches; a buffy line over the eye, under parts white tinged with pale sulphur yellow and thickly streaked with blackish.

L., 6.00; W., 2.25; T., 2.15.

Nest, on a bank or among the roots of a fallen tree. Eggs, four or five, white, marked with reddish brown and lilac.

LOUISIANA WATER THRUSH.

A conspicuous white line over the eye; upper parts wings and tail deep olivaceous brown; no wing bars or tail patches; under parts white tinged with creamy and streaked with black except on the throat and middle of belly.

L., 6.28; W., 3.25; T., 2.15.

Nest, on a bank or among the roots of a fallen tree. Eggs, four or five, white, spotted with various shades of brown and lilac.

CONNECTICUT WARBLER.

Adult male. Head, neck and breast ashy gray, lighter on the throat; eye ring white; rest of upper parts, wings and tail olive green; no wing bars or tail patches; below from the breast yellow; sides tinged with olive green.

Adult female. Upper parts uniform olive green; throat and breast grayish brown; below pale yellow.

L., 5.50; W., 2.75; T., 2.00.

Nest, on the ground. Eggs, four, creamy white, a few spots of purplish brown and black about the larger end.

MOURNING WARBLER.

Adult male. Head and neck bluish ash, the feathers of the throat and breast black margined with ash; no white eye ring; rest of upper parts, wings and tail olive green; no wing bars or tail patches; below yellow.

L., 5.50; W., 2.25; T., 2.25.

Adult female. Similar but duller, olive green above slightly grayer on head; breast grayish; throat whiter.

Nest, on or near the ground. Eggs, four, white, speckled with reddish brown.

MARYLAND WARBLER.

Adult male. A broad band across the forehead, on the cheeks and ear coverts, black, bordered behind by grayish; rest of the upper parts, wings and tail olive green; no wing bars or tail patches, throat and breast bright yellow, whitish below; under tail coverts yellow.

Adult female. No black mask; upper parts, wings and tail olive green; throat and breast yellowish.

L., 5.33; W., 2.20; T., 2.00.

Nest, on or near the ground. Eggs, four or five, white, rather thinly speckled with reddish brown, chiefly near the larger end.

YELLOW-BREASTED CHAT.

Upper parts, wings and tail olive green; line from the eye to the bill, one on the side of the throat and eye ring white; throat and breast bright yellow; below white; sides grayish.

L., 7.45; W., 3.00; T., 3.05.

Nest, in a bush near the ground. Eggs, four or five, white, evenly speckled with reddish brown.

HOODED WARBLER.

Adult male. Forehead and cheeks bright yellow; crown black, connected behind with the black throat; upper parts, wings and tail olive

green; outer tail feathers, with inner vane mostly white; below yellow.

Adult female. Similar but with the black on head and breast somewhat restricted and less clearly defined.

L., 5.50; W., 2.50; T., 2.25.

Nest, in bush or low tree. Eggs, four or five, white, rather thinly speckled with reddish brown chiefly about the larger end.

WILSON'S WARBLER.

Adult male. Forehead yellow, crown black; rest of the upper parts, wings and tail bright olive green; no wing bars or tail patches; under parts bright yellow.

Adult female. Similar but black cap small or wanting.

Immature. Like female.

L., 5.00; W., 2.20; T., 2.00.

Nest, on the ground. Eggs, four or five, white, speckled with reddish brown and pale lilac.

CANADIAN WARBLER.

Adult male. Upper parts, wings and tail gray, no wing bars or tail patches; crown spotted with black; line from the bill to the eye and under parts yellow; sides of the neck black; a necklace of black spots across the breast; under tail coverts white.

Adult female and Immature. Duller, no black on head or sides of throat.

L., 5.60; W., 2.50; T., 2.25.

Nest, in a bank or among roots. Eggs, four or five, white, speckled chiefly at the larger end with reddish brown.

REDSTART.

Adult male. Upper parts, throat and breast shining black, basal half of the wing feathers orange, end half and wing coverts black; basal two thirds of all but the middle tail feathers orange, end third and middle feathers black; sides of the breast and planks deep orange; belly white.

Adult female and Immature. Orange of the male replaced by dull yellow; head grayish; black ashy brown.

L., 5.40; W., 2.55; T., 2.25.

Nest, in the crotch of a small tree. Eggs, four or five, grayish white, spotted and blotched chiefly at the larger end with various shades of brown.

KINGLETS AND GNATCATCHERS.

These are, next to the Humming bird, the smallest birds we have, their want of size, however, being amply compensated for by their

constant activity in pursuit of their insect food, and the number of them that pass through the Province during their migrations. There are two species of them, the Ruby Crowned Kinglet and the Golden Crowned Kinglet, the latter being much more abundant. The names given them are sufficiently descriptive of the color of their crests to enable them to be easily identified when examined; in other respects they are almost indistinguishable. The Ruby Crown has a wonderfully loud voice for such a minute creature, and is a good singer. The Golden Crown has no song at all. Early in April myriads of these little birds pass over the country working their way northward, and may be seen in our orchards and shrubberies carefully searching every part of the trees and bushes for the insects and their eggs that are hidden from all eyes less keen than theirs, and cutting short the career of a vast number of insects before they have developed sufficiently to do mischief. Neither of them have as yet been positively ascertained to breed in the southern part of Ontario, but no doubt they do so in the evergreen woods to the north of us. About the end of September they return, their numbers increased by the broods of the year; they are not now in any hurry, but just loiter along toward the south, until the middle of November, when the last of the migrating host disappears. All the Ruby Crowns leave us, but there are always a goodly number of Golden Crowns which remain in our sheltered evergreen woods all through the winter. How such tiny creatures can resist the extreme cold of that season is a mystery; but they do it, and can even then find enough insects and their eggs (for they eat nothing else) to keep them in good condition.

They are expert in capturing small moths on the wing and no doubt destroy a great many of them, but the greatest service they render us is in destroying the eggs of the aphides scale insects and other insects which are too small to attract the attention of larger birds.

Blue-gray Gnatcatcher. In South Western Ontario this little bird is a regular though never a common summer resident. While it does not occur in sufficient numbers to be an important economic factor, yet it assists the warblers in keeping in check the foliage devouring insects which swarm the trees in summer.

KINGLETS AND GNATCATCHERS.

DESCRIPTION.

RUBY-CROWNED KINGLET.

Adult. Crown with a partly concealed crest of rich scarlet; upper parts, greenish olive; below whitish; wings and tail dusky, edged with yellowish; wing coverts whitish tipped.

Immature. Similar, but crown patch wanting during first year.
L., 4.50; W., 2.25; T., 1.70.

Nest, usually in a coniferous tree. Eggs, five to nine, whitish, faintly speckled with reddish brown at the larger end.



Ruby-throated Humming-bird.



Golden-crowned Kinglet.

GOLDEN-CROWNED KINGLET.

Adult male. Centre of crown bright reddish orange, bordered by yellow and black; a whitish line over the eye; rest of upper parts olive green; wings and tail dusky, margined with greenish yellow; under parts soiled whitish.

Adult female. Similar, but crown without orange, its centre yellow and bordered by black.

L., 4.50; W., 2.25; T., 1.70.

Nest, in coniferous trees. Eggs five to nine, creamy white, spotted with brown and lilac.

BLUE-GRAY GNATCATCHER.

Adult male. Upper parts bluish gray; forehead narrowly bordered by black; wings edged by grayish, the secondaries bordered with whitish; outer tail feathers white; changing gradually until the middle ones are black; under parts dull grayish white.

L., 4.50; W., 2.05; T., 2.00.

Nest, in a tree. Eggs, four or five, bluish white, thickly speckled with varying shades of brown.

CHIMNEY SWIFT.

The Chimney Swift, which closely resembles the Swallows in its habits, except that it never alights on the ground even to obtain the materials for its curiously constructed nest, may be mentioned in connection with them, its economic value being equally great.

DESCRIPTION.

Entire plumage dusky black; grayish on the throat; a sooty black spot before the eye; shafts of the tail feathers, extending beyond the vanes.

L., 5.40; W., 5.00; T., 1.90.

Nest, a basket of twigs, glued to the inside of a chimney or wall of a building with saliva of the bird. Eggs, four or five, pure white.

HUMMING-BIRD.

As this gay little creature flits from plant to plant or hovers before the flowers, thrusting its long beak deep into the corolla, the idea that it is rendering any particular service does not often occur to the casual observer; yet the bird has its own part to play in the economy of nature, and no bird is more highly specialized for the functions it is required to perform than this.

As an agent in the fertilization of many deep tubular flowers its services are very valuable. When the Hummers are working among

plants bearing blossoms of this kind their foreheads frequently become so covered with white or yellow pollen, as the case may be, that the real colour of the crown feathers is lost. The pollen so gathered is carried from flower to flower and thus fertilization is effected.

The commonly accepted idea that these birds feed only on the nectar of flowers is erroneous; that they sip some from the blossoms they visit is probably true, for in captivity they are fond of sweetened liquids, but that insects constitute their real food, is proven by examination of the contents of many stomachs. The insects taken are of course very minute, but perhaps none the less harmful on that account.

Humming-birds appear to be partial to small spiders, of these I have always found a good many among the stomach contents. In taking these spiders from the base of tubular flowers the Hummers were doing good service to the plants, for should the fertilizing organs in the blossom be covered with spiders web, no pollen could be carried in or out and so fertilization would be impossible.

DESCRIPTION.

Adult male. Upper parts brilliant glossy green; wings and tail dusky with purplish reflections; throat beautiful metallic ruby red bordered on the breast by whitish; rest of the under parts dusky.

Adult female. Similar but duller and no red upon the throat.

L., 3.75; W., 1.55; T., 1.15.

Nest, on the horizontal branch of a tree. Eggs, two, pure white.

WEED DESTROYERS.

It used to be the custom to divide birds into three classes with reference to the food they are supposed to eat, viz., birds of prey, insect eaters, and seed eaters. No such distinction can properly be made; all birds, even the Hawks and Owls, feed more or less upon insects, and nearly all the so-called seed-eating birds raise their young entirely upon insects. After the young reach maturity and the approach of cold weather reduces the insect supply, birds of this class display their usefulness by helping to clear the fields of the seeds of weeds as they ripen, and all through the winter they continue the work of harvesting this most objectionable crop.

Year after year farmers and gardeners expend large sums for labor applied for the destruction of noxious weeds, and would no doubt be willing to pay much more to fully protect their crops from injury by these pests if it could be done. Perfect immunity from insects and weeds can never be expected. We may, however, reduce the loss caused by them much below what it is at present, without the expenditure of any great amount of time or money by availing ourselves of the assistance of the natural enemies of both of them.

In 1881 Mr. F. E. L. Beal made an estimate of the amount of weed seed eaten by the common Tree Sparrow during the winter months in



Song Sparrow.

the State of Iowa. As the conditions in that state so far as the Tree Sparrow is concerned are similar to our own, I give the estimate to show the value of birds of this class as weed destroyers. Mr. Beal says; "upon the basis of one fourth of an ounce of seed eaten daily by each bird and supposing that the birds averaged ten to each square mile and that they remain in their winter range two hundred days, we shall have a total of 1,750,000 pounds or 875 tons of weed seed consumed by this one species in a single season."

SPARROWS, FINCHES, ETC.

This is a very large family, represented in Ontario by thirty-four species. Want of space prohibits my calling attention to the food habits of each of these in detail. It will, however, be sufficient for the purpose of this paper to refer particularly to those only which in some manner are specially beneficial or injurious to the crops usually cultivated for profit. All these birds are insect eaters in the summer months, and their young while in the nest are fed entirely on insects; but in the autumn, winter and early spring the mature birds subsist principally on the seeds of wild plants and forest trees.

Native Sparrows. Among the most familiar birds that spend the summer on and about the farm are the native Sparrows, commonly known as Grey Birds. The most abundant of these are the Chipping Sparrow, Song Sparrow, Vesper Sparrow, and Field Sparrow. The first three are to be found everywhere; the Field Sparrow is more locally distributed, but is sufficiently abundant to be of economic value where it occurs. These are all of the so-called seed eating class but the seeds eaten by them are the seeds of plants that can well be dispensed with. I have but rarely found any cultivated grains among their stomach contents, the only ones being a few oats in the fall. All through the summer a large part of the food of the adults consists of insects, and the young are fed entirely upon them until they leave the nest. As these birds raise two and sometimes three broods each season this means a vast number of insects taken from the crops. Small insects of all kinds are eaten, but the birds seem to show a preference for beetles, and a great partiality for the pea weevil or pea bug. These appear about the peas when they are in blossom, and I have often watched the Chipping Sparrow, Vesper Sparrow and Song Sparrow, together with the much abused House Sparrow, busily engaged in capturing these beetles about the pea vines, and specimens taken by me at this time had their crops and stomachs filled with them.

When the breeding season is over these Sparrows gather into flocks and may be found in large numbers in the weed patches too often left about the farm. Here they are doing service not less valuable than that rendered by their destruction of insect pests in the summer, and which has only to be observed to be appreciated.

In the spring we are visited by an innumerable army of Sparrows larger than those I have mentioned. These are the White throated

Sparrow, White-crowned Sparrow, and Fox Sparrow. They are on their way to their breeding grounds to the north of us. The Fox Sparrows pass through early in April, and rarely stay more than three or four days. The other two come later, and remain much longer, their migration lasting about three weeks. During all this time they frequent weedy places, where they may be observed industriously foraging for the seed of injurious plants. About the middle of September they return, having their number largely increased by the young raised during the summer, and they remain for about a month. During that time they visit nearly every weed patch and brush heap in the Province and feed luxuriously, not only on the seeds of the weeds we are most anxious to get rid of, but they also find in such places large numbers of mature insects which would lie there dormant during the winter ready to emerge in the spring to work mischief in the crops. Each female insect killed at this time means cutting off the source of supply of several hundreds of larvæ for the next year. In this way the birds are doing most excellent work for the farmer, the value of which can hardly be calculated in dollars and cents, and it is work that, with all our industry and ingenuity, we are not yet able to do for ourselves.

As winter comes on and our summer residents and spring and autumn visitors leave for the south, vast flocks of weed gleaners come from the north to take their place. The best known of these are the Snow Bird, Tree Sparrow, and Slate-Colored Junco. Large numbers of these birds remain with us all through the cold season, frequenting patches of weeds that carry their seed above the snow, and by their work materially lessening the number to spread over the country and germinate in the spring.

I have found that in confinement birds of this class will each consume on the average about a quarter of an ounce of small seed every day. Multiply this quantity by the number of native sparrows to be seen on any farm, and an idea will be obtained of the quantity of weed seeds disposed of by them during the season.

SPARROWS.

DESCRIPTION.

CHIPPING SPARROW.

Adult. Forehead black, a short grayish line in its middle; top of the head chestnut; a grayish line over eye and a black line behind it; back of neck grayish; back streaked with black, chestnut, and buffy, rump slaty gray; wing bars not conspicuous; under parts grayish white, whiter on throat; bill entirely black.

Immature. Breast streaked, no chestnut on crown; bill brownish. L., 5.37; W., 2.75; T., 2.30.

Nest, in trees or bushes. Eggs, four or five, pale blue, with brown or blackish marking at larger end.



Chipping Sparrow.



White-throated Sparrow.

SONG SPARROW.

Crown reddish brown, with a grayish median line; a grayish line over eye; a reddish brown line from behind eye to the nape; feathers of the back streaked with black and margined with brown and gray; greater wing coverts with black spot at their tips; tail reddish brown, the middle feathers darker along their shafts; sides of the throat with blackish streaks; breast with wedge shaped streaks of black and dark brown which tend to form a large blotch on the centre; sides washed with brownish and streaked with dark brown.

L., 6.30; W., 2.50; T., 2.60.

Nest, on the ground, or low down in bushes or brush heaps. Eggs, four or five, grayish or bluish white speckled with brown of various shades; very variable.

VESPER SPARROW.

Upper parts brownish gray streaked with black and a little buff; wings dusky, greater and middle coverts tipped with white; lesser coverts bright chestnut; tail dusky the outer feather mostly white the next one with less; under parts white; the breast and sides streaked with black and buff.

L., 6.15; W., 3.00; T., 2.30.

Nest, on the ground. Eggs, four or five, pinkish white, spotted with reddish brown.

FIELD SPARROW.

Top of head dull chestnut; a gray line over eye; back finely streaked with black, the feathers margined narrowly with ashy brown; middle and greater wing coverts tipped with white; under parts white tinged with buff on breast and sides.

Immature. Breast streaked with blackish.

L., 5.65; W., 2.50; T., 2.55.

Nest, on the ground or low down in a bush. Eggs, four or five, bluish white, variously marked with reddish brown.

WHITE-THROATED SPARROW.

Adult male. Centre of crown with a clear white stripe, bounded on either side by wider black stripes; a white stripe from the eye passes backward along the side of head, in front of which is a short yellow stripe; back chestnut brown streaked with black the feathers in part margined with grayish; rump grayish brown; bend of wing yellow; greater and median wing coverts tipped with white, forming wing bars; tail grayish brown; under parts grayish and darker on the breast; throat with a clear white patch.

Female and immature. The clear white of crown and throat replaced by buff.

L., 6.75; W., 2.90; T., 2.85.

Nest, in bushes. Eggs, four or five, bluish white, clouded and blotched rather heavily with reddish brown.

WHITE-CROWNED SPARROW.

Adult. Centre of crown with a clear white stripe bordered on either side by black stripes all of about equal width a clear white line over the eye passes back along the side of the head: nape gray: general colour above ashy grey, the middle of the back streaked with brown and whitish, greater and middle coverts tipped with white: tail dusky: under parts grayish white.

Immature. Similar, but sides of the crown rufous brown and centre of crown pale grayish brown.

L., 6.85; W., 3.00; T., 2.85.

Nest, on or near the ground in bushes. Eggs, four or five, pale greenish blue speckled at the larger end with reddish brown.

FOX SPARROW.

Upper parts rusty red: upper tail coverts and tail bright rufous: wings margined with rufous: below white, heavily streaked with rusty brown and blackish: tips of middle and greater coverts forming two whitish wing bars.

L., 7.25; W., 3.35; T., 2.85.

Nest, on the ground or in low trees or bushes. Eggs, four or five, pale bluish, heavily spotted with rusty brown.

SNOWFLAKE—SNOW BUNTING.

Adult in winter. Upper parts rusty brown, darker on the centre of the crown: back showing irregular streaks of black caused by the black bases of the feathers showing through their rusty tips: wings white, the end half of the primaries and inner secondaries black: outer tail feathers white, inner ones black, all these more or less edged with rusty: under parts white, the breast and sides washed with rusty.

Adult in summer. Whole head, neck, upper tail coverts and under parts white: back black: outer tail feathers white, inner ones black.

L., 7.00; W., 4.00; T., 2.75.

Nest, on the ground, in arctic regions. Eggs, four or five, white, scrawled and dotted with brown and lilac.

TREE SPARROW.

Top of head chestnut brown, in winter edged with ashy a grayish line over eye and a chestnut brown line behind it, back streaked with



Fox Sparrow.

chestnut brown, black and buff; upper tail coverts pale grayish brown; greater and middle wing coverts tipped with white forming whitish wing bars; primaries and tail feathers dusky with pale edges; below whitish tinged with ashy, an obscure dusky blotch on the middle of the breast.

L., 6.36; W., 3.00; T., 2.85.

Nest, on or near the ground. Eggs, four or five, pale, greenish blue, speckled with reddish brown.

JUNCO.

Adult male. Upper parts dark grayish slate colour; below abruptly pure white from the breast; two outer feathers of the tail and part of third white; bill flesh colour.

Adult female. Similar but duller; upper parts browner.

L., 6.25; W., 3.00; T., 2.75.

Nest, on the ground. Eggs, four or five, bluish white, speckled and blotched with reddish brown.

HOUSE SPARROW.

A member of this family about which there has been much controversy, is the imported European House Sparrow. This bird was introduced into Ontario about the year 1873 by some gentlemen who no doubt were under the impression that the sparrows would devote themselves exclusively to killing and eating the caterpillars that infest the shade trees in our towns. They either forgot or did not know that the Sparrow belongs to a class of birds whose diet consists of vegetable substance and insects in about equal proportion, and that the Sparrow, having attached itself to the haunts of man usually obtains its vegetable food from the plants and seeds cultivated by men for their own use. I have read many reports of so-called observers, who have stated that the House Sparrow never eats insects of any kind, that it drives away our native birds, and that it is altogether an unmitigated nuisance. Sweeping assertions of this kind are only conclusive evidence that the so-called observer cannot observe. No one with ordinary perceptive faculties can walk through our public parks, or along one of our streets where there are trees and grass in the summer time, without seeing some Sparrows industriously hunting for insects with which to feed their young, and should anyone have a Sparrow's nest under his verandah or about his house in such a position that some of the food brought by the parent birds to their young will fall where it can be seen, the proof that they do eat insects, and in large quantities too, will be very clear. The old birds also eat insects at this season, varying their diet with such undigested grain as they may find in horse droppings, and with bread crumbs and such like refuse from houses.

Sparrows like the majority of birds, will not often eat hairy caterpillars, but I have seen them eat the spiny larvæ of *Vanessa*

antiopa, which is one of our shade tree pests that few birds will touch. Besides this I have seen them take moths of almost any kind, including the large *Cecropia* and *Luna* moths and the Tussock moth (both the winged male and the wingless female), beetles of many kinds, even such large species as the aquatic *Dytiscus* which they find on the sidewalks beneath the electric lights to which the beetles are attracted at night, the green cabbage worm (the larvæ of the cabbage butterfly)—of these they eat great numbers. They also hunt about fences, and take the pupæ of this same butterfly. Currant worms and the mature insects are also taken in large numbers, as are also grasshoppers, and both the black and green aphides that occur on apple trees, and rose bushes, are eaten greedily. On one occasion a flock of Sparrows completely cleaned off the green aphids from some rose bushes near my windows. It took them several days to finish their work, but they did it effectually in the end.

About harvest time the Sparrows show their grain-eating proclivities. They then gather into large flocks, and, leaving the town where they were bred, visit the surrounding country and make serious raids upon the wheat and oats, and do more damage while the grain is standing, by beating it out than by eating it. It is in early spring, however, that the worst trait in the sparrow's character becomes apparent. Vegetation awakens after the long winter's sleep; the trees put forth their buds, and seedlings break through the soil. The Sparrow, probably needing an alternative after the hard fare of the winter, attacks all these: nothing green comes amiss to him, and then the gardener, wrathful at the loss of prospective fruit, vegetables and flowers, forgets the good qualities the bird has, and would have the whole tribe exterminated. Whether or not he would be the gainer by this is somewhat difficult to decide. My own opinion at present is, that the number we now have do as much good as they do harm, but that they should not be allowed to increase to any great extent.

The Sparrow is also charged with driving away our native birds. The charge is well founded only in the case of such birds as were formerly in the habit of building in holes and crevices about our houses, such as the Swallows and the Wrens. In the case of the Wrens the difficulty can easily be got over by placing their nest boxes low down, say about eight feet from the ground; the Sparrows will not then occupy them. But the Swallow problem is not so easy to solve. The trouble arises from the fact that the Sparrows remain here all through the winter and use the Swallows' nests in that season as roosting places. As spring comes they build in them, and so have possession when the Swallows return from the south. As they then, naturally enough, decline to turn out, the Swallows have to seek elsewhere for a home; the result being that we lose a valuable, purely insectivorous bird and get in the place of it one whose value is questionable. Continually shooting off the Sparrows as they appear seems to be the only remedy, and I think eternal vigilance would be required to make it successful in any place where the Sparrows are well established.



American Goldfinch.

That Sparrows are rather quarrelsome amongst themselves in the season of love-making is evident to everyone, but so far I have not seen them interfere with any other species whose nesting interests do not conflict with theirs. In my own neighborhood, House Wrens, Orioles, Vireos, Catbirds, Wilson's Thrushes, Robins, Chipping Sparrows, Song Sparrows, the American Goldfinch, and the Yellow Warblers have all bred in close proximity to many pairs of Sparrows, and have not been interfered with by them; but if I had not kept a pretty close watch over the nests, and taken out the eggs of the Cowbirds which were deposited therein, but few broods would have been successfully raised.

The House Sparrow has one particularly good trait which should not be overlooked, and that is its fondness for the seeds of the Knot grass or Knot weed and of the Dandelion. These pernicious plants frequently appear on our boulevards and lawns and sometimes destroy the grass completely. As soon as the seeds of these weeds form the Sparrows find it out, constantly visit them and greedily devour the seed, so that they are kept down to a very great extent and in some cases quite cleared out.

HOUSE SPARROW.

DESCRIPTION.

Adult male. Crown gray, bordered from the eye backward and on the nape by chestnut; lesser wing coverts chestnut, middle coverts tipped with white; back streaked with black and chestnut; upper tail coverts ashy; middle of the throat and breast black; sides of the throat white; belly whitish.

Adult female. Upper parts grayish brown, the back streaked with black and dull buffy under parts grayish white.

L., 6.33; W., 3.00; T., 2.30.

Nest, about buildings or in trees. Eggs, four or five, very variable, ground colour generally grayish or greenish white, speckled and blotched with varying shades of brown.

FINCHES AND TANAGERS.

The Purple Finch (the adult male of this species is crimson, not purple) in the spring is sometimes injurious in orchards and gardens, where it destroys the buds of fruit trees. They will also devour great quantities of sunflowers and other seeds. They are not, however, sufficiently numerous to cause much loss.

Wild Canary. A very useful weed destroyer is the American Goldfinch or Wild Canary as it is commonly called. The majority of these little birds remain with us in Southern Ontario all through the year. In winter they gather into flocks and resort to the evergreen woods, where, in their dull brownish yellow plumage of that season they

are not often recognized. At this time their food consists of the seeds of the hemlock and birch, and of such plants as stick up through the snow. On mild days flocks of them may sometimes be seen visiting the weed patches about the clearings. In the summer they scatter all over the country, frequently nesting in the small trees about the farms and orchards. They are not insect destroyers to any appreciable extent, their favorite food being the seeds of some of our most noxious plant enemies, such as the Dandelion, Canada Thistle, and others bearing plumed seed. The first appearance of these birds in the cultivated parts of the country is generally co-incident with the seedling of the Dandelion. As soon as the seed is formed numbers of these birds, assisted by some of the sparrows I have mentioned, the Purple Finch and Indigo Finches, may be seen flitting from head to head eagerly feeding upon it, and so preventing a greater spread than we have of this troublesome plant. By the end of July and on through August the Canada and other thistles are forming and ripening their seeds. The little Goldfinches fairly revel in these. Their sharp beaks are adapted for probing the involucre of the plants and extracting the seed from which they first cut off the plume, and then devour the seed.

This class of weeds is one of the worst pests we have to contend with, and is very difficult to get out of the land where it has established itself. As it is we are overburdened with it, and without its natural enemies to assist us in keeping it down we should find the contest much more difficult to carry on.

FINCHES.

DESCRIPTION.

PURPLE FINCH.

Adult male. Entire body crimson, brightest on the head, upper tail coverts and breast; streaked and washed with brown on the back; white on the belly; wings and tail dusky, the outer webs of the feathers finely edged with red.

Adult female. Upper parts grayish brown finely streaked with black; wings and tail dark grayish brown; under parts white heavily streaked with brown; a whitish line over the eye.

L., 6.00; W., 3.25; T., 2.30.

Nest, in low coniferous trees. Eggs, four or five, blue, spotted and scrawled at the larger end with purplish brown.

INDIGO FINCH.

Adult male. Rich blue, darkest on the head and throat; lores, blackish; wings and tail black, the quills margined with blue.



Purple Finch.

Adult female. Upper parts uniform cinnamon brown without streaks, wings and tail dusky the quills usually slightly margined with blue; under parts whitish brown indistinctly streaked, belly whiter.

L., 5.50; W., 2.55; T., 2.10.

Nest, in a low bush. Eggs, three or four, pale bluish white.

SCARLET TANAGER.

Adult male. Bright scarlet, wings and tail black.

Adult female. Upper parts clear olive green; below clear greenish yellow.

L., 7.25; W., 3.75; T., 2.10.

Nest, on the horizontal limb of a tree. Eggs, three or four, pale bluish white, speckled with reddish brown and lilac.

REDPOLL.

Adult male. Crown very deep crimson; back grayish brown, the feathers margined with buff; upper tail coverts white or rose pink; wings and tail dusky the feathers more or less edged with whitish; middle of the throat black; breast in birds of high plumage suffused with rose pink; sides streaked with blackish.

Adult female. Similar, but without pink on breast or tail coverts and sides more heavily streaked.

L., 5.50; W., 2.75; T., 2.33.

Nest, in a low tree. Eggs, four or five, pale bluish, spotted with reddish brown.

PINE FINCH—SISKIN.

Above, dull olivaceous streaked with dusky and brown the feathers margined with pale grayish; wings dusky most of the feathers margined with yellow and yellow at the base; tail dusky all but the middle feathers yellow at the base; under parts whitish and heavily streaked with dusky.

L., 5.00; W., 2.75; T., 1.85.

Nest, in coniferous trees. Eggs, four or five, pale bluish white, thinly spotted with reddish brown.

GROSBEAKS.

The Rose-breasted Grosbeak is one of the largest and most beautiful of the family, and is of more than usual interest because it is one of the very few birds that will eat the Colorado potato beetle and its larvæ, and also the larvæ of the Tussock moth, this last being a hairy caterpillar, very destructive to almost all shade and orchard trees. A specimen of this bird in my possession eats both these insects readily. Unfortunately, these Grosbeaks are of a retiring disposition,

and usually resort to the seclusion of the woods, but it is one of the few species that seems to be increasing in Ontario, and if unmolested it may possibly become more familiar in its habits. If so, its services in lessening the number of Tussock moths would be of great value. None of the native members of this family are addicted to eating the ordinary grain or fruit crops.

GROSBEAKS.

DESCRIPTION.

ROSE-BREASTED GROSBEAK.

Adult male. Head, throat and back black; upper tail coverts white barred with black; wings black primaries white at the base, and wing coverts tipped with white; tail black the outer feathers tipped with white on the inner web; breast bright carmine; under wing coverts rose red; rest of under parts white.

Adult female. Upper parts grayish brown the feathers margined with buffy gray; a buffy line down the centre of crown and a white line over the eye; wings and tail dusky brown, wing coverts tipped with white; under wings coverts yellow, the rest of the under parts creamy streaked with brown.

L., 8.12; W., 4.00; T., 3.00.

Nest, in a low tree. Eggs, four or five, pale blue, much spotted with reddish brown.

PINE GROSBEAK.

Adult male. Chiefly carmine, darkest and streaked with dusky on the back, fading to rose red on the upper tail coverts and breast; wings dusky with two white bars; tail dusky.

Female. Ashy gray, crown, upper tail coverts and breast more or less olive yellow.

L., 9.00; W., 4.35; T., 3.65.

Nest, in the far north, on low coniferous trees. Eggs, four or five, pale greenish blue, spotted and blotched with brown and lilac.

EVENING GROSBEAK.

Adult male. Forehead and line over the eye yellow, crown black, sides of head olive; upper tail coverts yellow; tail black; wings black, end half of the secondaries and their coverts white; scapulars and belly yellow; bill greenish yellow.

Adult female. Brownish gray; lighter and more or less tinged with yellow on the under parts.

L., 8.00; W., 4.50; T., 3.50.

Nest, in North West, on a low tree. Eggs, three or four, greenish spotted with brown.



Rose-breasted Grosbeak.



Horned Lark.

PRAIRIE HORNED LARK.

Prairie Horned Lark. These birds have become summer residents with us only within the last thirty years, prior to that a Horned Lark rather larger and darker than the one we now have, used to visit us in small numbers with the snow birds in winter; of late this winter form has rarely been seen. The Prairie Horned Lark is the first of our migrants to distribute itself through the country, usually becoming abundant in the southern frontier counties early in February, when those that have remained in this part of the country are joined by those that have spent the winter further south, and they spread all over the cultivated parts of the Province before the snow disappears. It is the first of our small birds to breed. I have several times found their nests containing eggs in the first week in April, and have seen young able to fly a little as early as the 15th of that month. Two or sometimes three broods are raised in the season.

These birds frequent open fields and tracts of fallow, or sandy land, and feed on the insects they find in such places, and on the seeds of many of our most troublesome weeds. Sometimes in the autumn I have noticed a few grains of oats among their stomach contents but never at any other season. As these larks, during their stay with us, obtain nearly all their food from the cultivated lands, and that food consists of just the things we are most anxious to keep in check, the services they render are very valuable.

In November the bulk of the Horned Larks leave us and go south. A good many, however, remain in Southern Ontario, if the winter is not too severe, and now that the custom of hauling out manure onto the fields through the winter is becoming general the number of birds, that stay seems to be increasing.

PRAIRIE HORNED LARK.

DESCRIPTION.

Adult male. Forehead line over the eye, ear region and throat white more or less tinged with yellow; fore part of the crown, a tuft of elongated feathers on either side of the head, a mark from the bill below the eye and then downward to the side of the throat, and a patch on the breast black; back of the head and neck and upper tail coverts vinaceous, more or less washed with grayish brown; back grayish brown, edged with brownish ash and tinged with vinaceous; wing coverts deep vinaceous tail black, the outer vanes of the outer feathers margined with white, the middle feathers broadly margined with brownish and vinaceous; below white.

Adult female. Similar, but duller and the black much less sharply defined.

L., 7.75; W., 4.25; T., 2.84.

Nest, on the ground in open fields. Eggs, four or five, greyish white, speckled with dusky and brown.

MOURNING DOVE.

Besides the species I have referred to there are many others assisting us as weed destroyers amongst them the Mourning Dove. This is the only bird I know that feeds exclusively on seeds, and while it may possibly at times consume a little grain yet its services in keeping down some of our most noxious weeds will amply pay for what it takes, unless perhaps it should become too abundant in the country, a condition not likely to happen in these days of breech-loaders, etc. I have on several occasions shot these doves in the autumn, and on picking them up found their crops so full of weed seeds that they burst on striking the ground. In several cases I noticed that the bulk of the food contained in the crop consisted of seeds of the bindweed, a plant that becomes very injurious when established on cultivated land.

DESCRIPTION.

Adult male. Upper parts grayish olive; forehead vinaceous; crown bluish slate colour; sides of the neck with brilliant metallic reflections of purple, green and bluish; a small black mark below the ear and several others on the wing coverts and scapulars; middle tail feathers like back; the other slaty blue for the basal half, then crossed with a black bar, then white; breast vinaceous; below creamy buff.

Adult female. Similar but duller, less iridescence; breast and forehead grayish brown.

L., 11.80; W., 5.75; T., 5.50.

Nest, on a low tree, or overgrown fence. Eggs, two, pure white.

GAME BIRDS.

Of our game birds the only two that are of economic importance as insect or weed destroyers are the Ruffed Grouse, commonly called "Partridge," and the Quail or "Bob White."

The Ruffed Grouse sometimes visits the edges of cultivated fields lying next to woodlands, and there feeds upon weed seeds to a limited extent, but as a grasshopper destroyer this bird is of considerable value.

In the latter part of August and through September "Partridges" are fond of getting out on grassy places at the edge of bush pastures where they gorge themselves upon these insects. If examined at this season their crops will often be found to be packed full of them.

In the cool mornings and evenings of September grasshoppers are lethargic and may be found on the weed stems in great numbers. At such times the "Partridges" can get them easily without exposing themselves too far from cover, and they generally avail themselves of their opportunity, thereby doing themselves and the farmers much good.

The Quail. This beautiful game bird besides furnishing sport and delicious food, is an insect eater and a notable weed destroyer, and therefore of the greatest possible economic importance to the farmer



Quail Bobwhite

and fruit grower. Unfortunately for the rest of the Province this bird is confined to our southern and south western counties, and even there it is not now nearly as abundant as it used to be, or as it should be.

The Quail is one of the birds that is directly beneficial to the agriculturist; all its life is spent among the crops upon which he expends his labour and from which he derives his profit, and it is constantly engaged in destroying the insects that are most destructive to the plants raised by his care under cultivation.

For the first two or three months of their lives young quail feed almost entirely on insects, and each one will, while it is growing, consume nearly its own weight of them every day. To obtain this quantity the number eaten must be very large. As the birds approach maturity they vary their diet by adding the seeds of various weeds, grasses, etc., to their fare, but still take large numbers of insects so long as they are obtainable, grasshoppers in the autumn forming one of the principal articles of their food. After these fail they are compelled to find their sustenance in the stubble fields and weed patches, where they glean sufficient food to keep themselves in good condition until the supply is cut off by deep snow; then it is that our quail suffer from lack of food and die in large numbers from starvation and cold.

If well fed, quail can withstand the severity of our winters quite readily, but if starved they like all animals, gradually succumb to cold, and it is by reason of their inability to obtain food when deep snow covers the ground that so many are lost every winter. This could be prevented if the farmers and fruit growers in the quail counties would afford the birds a little food and protection to carry them over the latter part of the winter season in which the greatest mortality occurs.

A simple method of affording the requisite protection and food is to arrange three or four forked poles so that they support each other in tent form, and throw over them a little pea straw, buckwheat stalks, or any such waste stuff, so as to have a hollow underneath, into which the birds can go and be safe from storms. Into these places throw a few measures of tailings or waste grain occasionally, and the quail will be able to maintain themselves in safety.

For the slight trouble necessary to provide a few of these shelters around a farm and orchard the farmer and fruit grower will be amply repaid the following season by a good stock of quail to keep down the insects and weeds that destroy his crops during the summer, and to provide sport for himself and his friends in the autumn.

DESCRIPTION.

QUAIL—BOB-WHITE.

Adult male. Upper parts variegated with chestnut, black, gray and tawny; interscapulars with broken black bars; inner vane of tertials widely margined with creamy buff; tail ashy gray, the inner feathers

finely mottled with buffy; front of the crown, a band from the bill to beneath the eye and a band on the upper breast black; throat and a broad line from the bill over the eye white; sides chestnut, margined with black and white; lower breast and below white barred with black.

Adult female. Similar but duller and the throat, line over the eye, forehead and lores buff; little or no black on the upper breast.

Nest, on the ground, arched over by grass or weeds. Eggs, ten to fifteen, pure white.

RUFFED GROUSE—PARTRIDGE.

A very variable species; general colour of the upper parts much variegated with black, chestnut buffy and gray, sometimes chestnut and sometimes gray prevailing; sides of the neck with large tufts of broad glossy black or coppery colored feathers; tail varying from pearly gray to rich chestnut, irregularly barred and mottled with black; a broad black or coppery band near the end; tip gray; throat and breast creamy barred with blackish or brown.

Nest, on the ground in woods. Eggs, eight or ten, buff, sometimes faintly speckled with brown.

CONCLUSION.

There are other families of birds more or less directly beneficial or injurious to our interests, but space will not permit an extended notice of each. Even the little Humming-bird which is generally supposed to feed only on the nectar of flowers is a destroyer of insects, and also helps to pollenize many blossoms. Enough, I trust, has been said to impress upon my readers the great value of the majority of our birds to the agriculturist.

I have seen estimates of the amount of damage done to the crops by insects in various countries, including our own Province, and although they usually stand at some millions of dollars annually, I believe they are much below the mark. It is difficult to form an estimate of the yearly loss from this cause to ordinary field crops, because the plants are crowded so thickly together that a large proportion may be destroyed in the earlier growing stages without being noticed, and it is only when the matured crop fails to reach the expected quantity that we realize the fact that something has gone wrong, but unfortunately it is then too late to remedy the matter. In our gardens we can more readily see the amount of injury done by insects, and can take measures to reduce it; but in spite of our efforts the loss is still enormous. What would it be if we had not the birds to assist in keeping down the swarm of insect life? The great trouble now is that we have not a sufficient number of birds to keep the balance between vegetable and insect life in our favour.

We know that the common cut-worm causes much loss every year in spite of the fact that almost all our ground-feeding birds eat great

numbers of them, and that the birds that feed among the trees and on the wing destroy very many of the moths which produce them, and so we can easily imagine what the result would be to the crops if these creatures were allowed to increase unmolested by their natural enemies; so prolific are they, that I believe the increase of one season would provide a sufficient number to clear off all the crops we cultivate.

A constant war is being carried on between the insect world and the vegetable kingdom. The laws of nature would keep the balance about evenly adjusted. But man requires that it should be inclined in favour of the plants he cultivates for his own use. To obtain this end it is necessary that we should carefully protect and encourage all the forces that will work on our side against our insect enemies, and while they are not the only ones, yet the birds are the most important allies we can have in the struggle. We cannot very well increase their number or efficiency by any artificial means, but we can protect them from such of their natural enemies as occur in our own neighborhood, and we can encourage them to remain and breed about our farms and gardens. If this was done over the country generally we should find ourselves amply repaid for the small amount of trouble expended, by the protection they would give our plant life against its destructive enemies.

Experience has shown that laws are of but little use in accomplishing reforms, unless sustained by an intelligent, sympathetic public opinion, and this is what we require to cultivate on behalf of our birds. We have a protective law, which is amply sufficient if it was only properly enforced. Every person can protect the birds upon his own lands, and if he would only do so, the benefits to be derived from his efforts would soon be apparent.

Not only should we defend and encourage our birds for the good they do in protecting our crops, but also from higher motives. There is nothing in nature more beautiful than the living bird. Nothing that shows more clearly the wonderful adaptation of the created thing to the purpose it is intended to serve, and no form of life that can better gratify the more refined senses of mankind than our feathered friends; their graceful forms and beautiful colouring excel the flowers, while they alone are gifted with the power of producing that exquisite music which above all things charms the lover of nature.

ACT FOR THE PROTECTION OF INSECTIVOROUS AND OTHER BIRDS.

Chapter 289, R.S.O. 1897.

HER MAJESTY, by and with the advice and consent of the Legislative Assembly of the Province of Ontario, enacts as follows:

1. Nothing in this Act contained shall be held to affect *The Ontario Game Protection Act*, or to apply to any imported cage birds

or other domesticated bird or birds generally known as cage birds, or to any bird or birds generally known as poultry.

2.—(1) Except as in section 6 of this Act provided, it shall not be lawful to shoot, destroy, wound, catch, net, snare, poison, drug or otherwise kill or injure, or to attempt to shoot, destroy, wound, catch, net, snare, poison, drug, or otherwise kill or injure any wild native birds other than hawks, crows, blackbirds and English sparrows, and the birds especially mentioned in *The Ontario Game Protection Act*.

(2) Any person may, during the fruit season, for the purpose of protecting his fruit from the attacks of such birds, shoot or destroy, on his own premises, the bird known as the robin without being liable to any penalty under this Act.

3. Except as in section 6 of this Act provided, it shall not be lawful to take, capture, expose for sale or have in possession any bird whatsoever, save the kinds hereinbefore or hereinafter excepted, or to set wholly or in part any net, trap, springe, snare, cage or other machine or engine, by which any bird whatsoever, save and except hawks, crows, blackbirds and English sparrows, might be killed and captured; and any net, trap, springe, snare, cage or other machine or engine, set either wholly or in part for the purpose of either capturing or killing any bird or birds save and except hawks, crows, blackbirds and English sparrows, may be destroyed by any person without such person incurring any liability therefor.

4. Save as in section 6 of this Act provided, it shall not be lawful to take, injure, destroy or have in possession any nest, young or egg of any kind whatsoever, except of hawks, crows, blackbirds and English sparrows.

5. Any person may seize, on view, any bird unlawfully possessed, and carry the same before any justice of the peace, to be by him confiscated, and if alive to be liberated; and it shall be the duty of all market clerks and policemen or constables on the spot to seize and confiscate, and if alive to liberate, such birds.

6. The chief game warden for the time being, under *The Ontario Game Protection Act*, may on receiving from any ornithologist or student of ornithology, or biologist, or student of biology, an application and recommendation according to the forms A and B in the schedule hereto, grant to such an applicant a permit in the form C in said schedule, empowering the holder to collect, and to purchase or exchange all birds or eggs otherwise protected by this Act, at any time or season he may require the same for the purposes of study, without the liability to penalties imposed by this Act.

7. The permits granted under the last preceding section shall continue in force until the end of the calendar year in which they are issued, and may be renewed at the option of the chief game warden for the time being under *The Ontario Game Protection Act*.

8.—(1) The violation of any provision of this Act shall subject the offender to the payment of not less than one dollar and not more than twenty dollars, with costs, on summary conviction, on information or complaint before one or more justices of the peace.

(2) The whole of the fine shall be paid to the prosecutor unless the convicting justice has reason to believe that the prosecution is in collusion with and for the purpose of benefiting the accused, in which case the said justice may order the disposal of the fine as in ordinary cases.

(3) In default of payment of the fine and costs, the offender shall be imprisoned in the nearest common gaol for a period of not less than two and not more than twenty days, at the discretion of the justice.

9. No conviction under this Act shall be quashed for any defect in the form thereof, or for any omission or informality in any summons or other proceedings under this Act so long as no substantial injustice results therefrom.

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE.

Farm Underdrainage: Does It Pay?

BY W. H. DAY, B.A., PROFESSOR OF PHYSICS.

Underdrainage has been known and practised in Ontario to some extent from the days of the early settlers, when the only materials at hand for pipes were slabs and stones. As the wooden pipes decayed and the stone ones filled with sediment, they gave place to clay tile, and for many years these have been laid in comparatively large numbers, and usually with gratifying results, as is shown by the fact that the most enthusiastic advocates of tile drainage to-day are those who have done most of it. Yet, despite this success, the practice of underdrainage has spread comparatively slowly. To be convinced of this one has only to travel over the province in April, May, and sometimes June, and note the thousands upon thousands of farms in well-settled districts, amounting to millions of acres, that are so wet in whole or in part that seeding operations are delayed from two to six weeks, and then travel again in August and see these same large areas producing only one-quarter to half a crop, while dry land in the same vicinity yields a full crop. In several cases practically whole counties need underdraining, and there are some counties where tile are not yet manufactured, and where practically no underdrainage whatever has been done. With these facts before us, and being ever more strongly emphasized by widening experience and by accumulating data, and knowing at the same time that many farms and various districts once wet and useless have been transformed by underdrainage into the most productive in the land, one cannot but wonder why the practice has not spread more generally into other wet districts. Contact with the people tells us why. To begin with, the results of underdrainage are not generally known, the immensity of which truth only an intimate knowledge of the facts will reveal. Secondly, the critical operations of drainage are even less understood than its benefits—farmers, generally, have no way of telling whether they have fall enough for underdrainage, what the grade of a proposed drain should be, nor any method of digging to a grade, or planning a general drainage system; and, fearing disaster in undertaking to drain by guess, they leave it strictly alone. Thirdly, there is an impression abroad that a poor man cannot afford to drain, as the cost is so great. And, lastly, the

scarcity of labour is preventing many men from draining who are fully impressed with its value. Four years of contact with hundreds of farmers eager for knowledge on drainage has led us to these conclusions; it has also shown us the need of literature to spread information and dispel illusions concerning drainage. It is hoped that this bulletin, and its sequel, No. 175, will contribute to these ends.

As the farmer is pre-eminently a practical man it is the writer's first aim to treat the subject from the practical side.

RESULTS OF UNDERDRAINAGE.

In the spring of 1909 the Department of Physics, which for several years has been making drainage surveys for farmers in all parts of the Province, wrote a large number of the men for whom surveys had been made in 1906, 1907, and 1908, asking them if they had put in any of the



Fig. 1. Cutting wheat on the farm of Mr. J. A. Fletcher, Fletcher P.O., Kent. Farm was a "mud pond" before it was underdrained. (See page 3.)

drains surveyed by the department, and, if so, to give their experience, paying special attention to cost of drains, difference in dates of seeding, difference in growing crops, and increase in yield. A few others who had done drainage in earlier years were also written to. Perhaps the most effective way of presenting their reports is to give first quotations from a few of their letters under their own names, and then summarize all the reports. In this way farmer can talk to farmer at first hand through this College bulletin, even though hundreds of miles apart.

QUOTATIONS FROM REPORTS BY MEN WHO HAVE DRAINED.

WILLIAM BELL, Washago, Simcoe: "I drained eight acres you surveyed for me in 1907. It had produced nothing previously. Last year I grew a fairly good crop of oats on it, which yielded 33 bushels per acre. Following is a statement of outlay and results:

Cost of draining 8 acres, \$290.90—\$35.11 per acre, including a 6-inch main to drain other land as well as this.

Returns—33 bushels oats at 45 cents—\$118.80, nearly half cost of drainage, and straw yet to be accounted."

T. S. BIGGAR, Manager, Walker Sons, Walkerville, Essex: "On our drained land this year, 1909, we had 80 bushels of shelled corn per acre, while the undrained gave us only 56 bushels. Of oats we had 66 bushels on drained and 37 on undrained. In 1908 the drained land gave us twice as much as the undrained. We have tiled 87 acres this year, and purpose tiling much more next year."

J. H. CLARE, Chapman, Hastings: "Fields that previously were unfit for crops at all can now be seeded on even date with high land; and, while before they grew nothing but coarse grass, now they yield per acre:

Hay—2 to 3 tons .

Oats—40 to 100 bushels.

Barley—30 to 50 bushels.

Corn—14 feet high."

JAMES CLAYTON, Cedar Springs, Kent: "In 1901 I drained 8 acres, at a cost of \$112, or \$14 per acre; 8 acres right across the fence was not drained. In 1902 both fields were sowed to beans; 8 acres drained land gave 302 bushels, which sold for \$456; 8 acres undrained land gave 24 bushels, which sold for \$37.

"Gain, \$419, nearly four times the cost of drainage.

Author's Note: This example shows the value of underdrainage in specialized agriculture.

"In 1903 both fields grew fall wheat. Eight acres drained land gave 45 bushels per acre; 8 acres undrained land gave 25 bushels per acre. Gain, 20 bushels of wheat per acre. 1904—There was drained land on both sides of that fence."

W. J. COHOE, New Durham, Brant: "About two-thirds of the oat field was drained last fall, and this went in in good condition, April 30th. The rest of the field is porous soil, but rather level and higher than the drained part, and we sowed it three weeks later; and I must say it was not really fit then, but, anxious to get it sowed, we 'mudded it in.'"

NATHAN DAY, Powles' Corners, Victoria: "I drained a 10-acre field some fifteen years ago, at a total cost of \$145, or \$14.50 an acre, the drains being four rods apart and two and a half feet deep. It was a muck soil, from a foot to a foot and a half deep, underlaid with a heavy clay. Before draining it was the wettest field on the farm, and would grow only hay and oats, and never more than a half crop of them, and often not that, and was never sowed before June. Since draining it is the second driest field we have, and will grow a full crop of anything that can be grown on the high land of the farm. It has been sowed in April every year but one since it was drained. The drains paid for themselves in two years. If I were draining this field again I would put a drain every two rods, for the crops are always better right over the drains than halfway between."

J. A. FLETCHER, Fletcher, Kent: "This section of the country (Tilbury East Township) is on a fair road to improvement. Farmers are beginning to realize in hard cash that they cannot farm without drainage. I have enclosed a photo (Fig. 1), taken on my farm (cutting wheat), which shows the advantage of thorough drainage. This farm of mine was practically a mud-pond

seven years ago, when I bought it, and to-day I completed harvesting one 18-acre field of corn, which gave me the handsome return of over 3,000 bushels."

F. W. HUNTLEY, Sutton, York: "We drained part of the land surveyed, and this year a fine crop of fall wheat is growing on land that formerly was counted too wet for anything but meadow."

WILLIAM LAMB, Brantford, Brant: "I think underdraining the best investment I can make on my farm."

JOSEPH LAPP, Cedar Grove, York: "I drained five acres, with drains 120 feet apart (110 rods on five acres). Drained another field, with drains 30 feet apart and 3 feet deep. In each case the gain in the first crop paid the full cost of the drainage.

"My general conclusion is this: Where drainage is at all required, its entire cost will be repaid by the increase in the first two crops, but in most cases by the increase in the first crop alone. Our own experience is the latter."

A. LEACH, Farm Manager for W. F. Maclean, M.P., Donlands, York: "The cedar swamp field south of the barn, which you surveyed, and which, as you will remember, was so wet, even in the driest part of the summer, that one could not walk on it without getting wet, was drained last fall; and this year, in spite of the heavy rains which delayed all spring farming operations, it was the driest field we had when we came to cultivate it, although much of our land is high and rolling. The crop sowed on it is coming on fine, and gives every indication of good, stiff, strong growth."

JAMES MARSHALL, Hamilton, Wentworth: "In fifteen years I have put in over twenty miles of drains on my farm, and my only regret is that I have not used more of my spare time and attention to complete the underdraining and bring the whole farm into a better state of cultivation. In 1897 I drained a 12-acre field, at a cost of \$460, almost \$40 an acre, drains being 25 to 30 feet apart and 3 feet deep. The next year this field yielded 80 bushels of oats per acre, while the adjoining field of similar soil, but not drained, yielded only 45 bushels per acre, thus gaining 35 bushels of oats per acre by drainage."

Author's note: Price of oats by to-day's paper, 44 cents. Value of 35 bushels at 44 cents, \$15.40, considerably more than one-third price of drainage, and the increase of straw yet to be counted.

"Another year I got the following results: 45 bushels wheat on drained; 25 bushels wheat on undrained, thus gaining 20 bushels."

Author's note: Wheat to-day, price \$1. Value of 20 bushels, \$20, over half cost of drainage, and straw yet to be accounted.

R. H. McCURDY, Vienna, Elgin: "Last fall I drained two acres that formerly would grow nothing. They were low spots in a field. Cost \$17.50 an acre. This year I had 30 bushels of fall wheat per acre on them, while the higher land gave only 15 bushels. The drains more than paid for themselves with this one crop. The whole 30 bushels was gain, as those spots would grow nothing before." (See Figures 2 and 3.)

Author's note: Value of 30 bushels at to-day's market price, \$30.

JOHN MCINTAGGERT, Brechin, Ont.: "Last fall I drained the lowest of the land you surveyed, putting in over 500 rods of tile drains. Other years I was unable to work on it till the last of seeding, but this year it was the first ground I could work on, and was all of a month ahead of high land." (See Figs. 4 and 5.)

Author's note: With regard to Mr. McIntaggert's case, a very interesting fact came to my knowledge recently. His drains, about five miles, on fifty acres, were laid out by the Department in June, 1908, and at the

conclusion of the survey a drainage demonstration was held, at which many of the neighbours were present, one of whom applied for a survey of his farm, but it could not be undertaken then, and was later turned over to Mr. J. H. Hare, District Representative of the Department of Agriculture for the county of Ontario. In June of the present year Mr. Hare went to the locality to make the said survey, and in the mean-

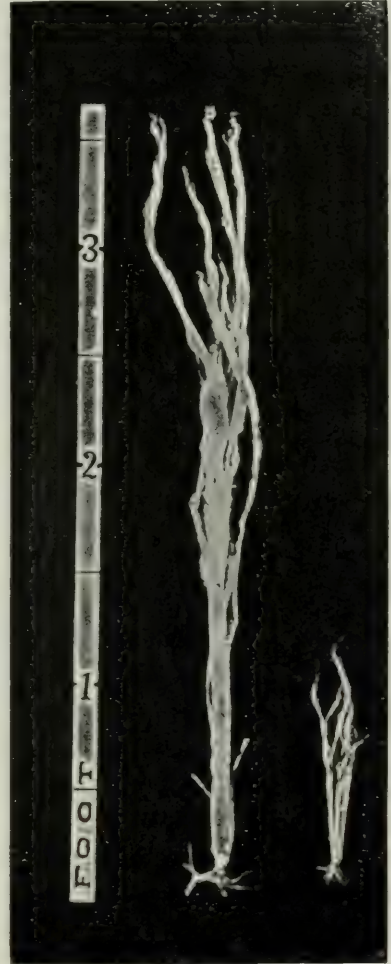
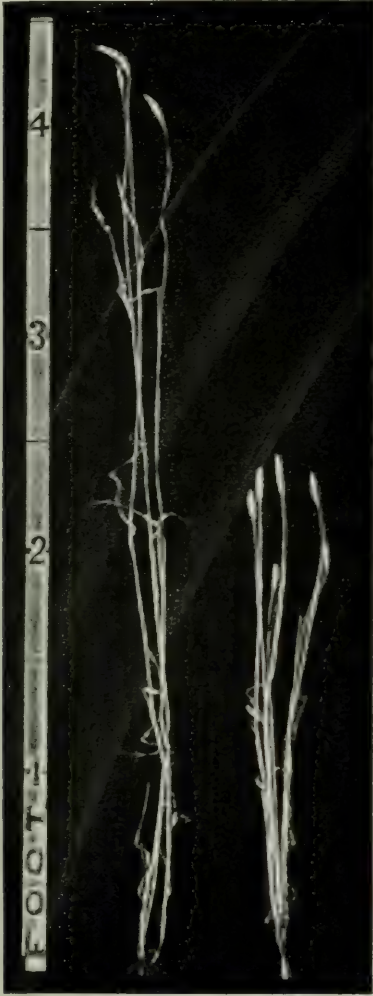


Fig. 2. Fall wheat on drained and Fig. 3. Corn on drained and
undrained land.

Specimens sent by Mr. R. H. McCurdy, Vienna, Elgin County.

time Mr. McIntaggert had put in two and a half miles of drain on about twenty-five acres, and the neighbours had been watching results. What they thought may be judged from the fact that Mr. Hare had to make *nine surveys instead of one* before leaving the community, and we may also infer that the samples sent by Mr. McIntaggert, and shown in Figures 4 and 5, do not show any more difference or speak any more emphatically when singled out than did the crops as a whole from which they were chosen.

J. P. McKIM, Caledon, Peel: "I have drained some muck-holes, which were always so wet that we had to sow around them even in a dry spring. This year they were the first of the field ready to sow. I cannot compare dates, as I never could sow them before."

JOHN A. McMAHEN, Petrolea, Lambton: "This year (1909) I had barley sowed on drained and on undrained land. The drained land yielded 15 bushels more per acre than the undrained, and twice as much straw." (See Fig 8.)

PETER W. SCOTT, Belgrave, Huron: "The lowest field on my farm has drains 100 feet apart, and this spring it was the driest field and ready to cultivate the earliest. I consider in a year like this thorough drainage doubles the value of land for cultivation." (See Fig. 6.)

SMART BROS., Collingwood, Simcoe: "We put down some 17,000 feet of tile drains last fall, according to your survey, and everything worked out perfectly. The cost was \$973. The greater part of the land drained had never been cropped before, on account of being too wet, but this year we have tomatoes planted on some of the lowest of it; also carrots, beets, parsnips, etc. We would not think of working undrained land in our business.

"We cannot say too much in praise of the drainage work of your department, as we have done considerable tile draining before, and therefore know the advantage of your system."

J. C. THOMAS, Blytheswood, Essex: "Part of my seed-corn plot this year was on drained land and part on undrained. The results were as follows: Stalks, per acre, 4,000 lbs. on drained and 2,320 lbs. on undrained. Shelled corn, per acre, 82 bushels on drained, 29.7 bushels on undrained. In my general corn crop I got the following results: Stalks, per acre, on drained 2,970 lbs., on undrained 1,420 lbs. Shelled corn, per acre, 53.3 bushels on drained and 18.9 bushels on undrained."

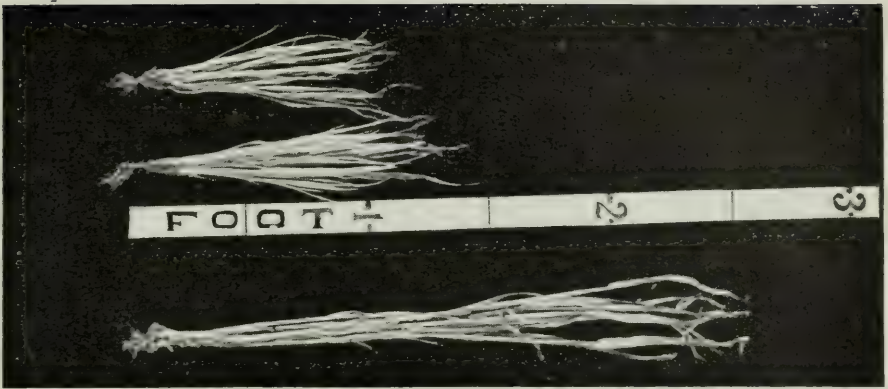
DIFFERENCE IN DATES OF SEEDING.

Twenty-six of our correspondents gave us the difference in dates of seeding their drained and undrained land. A summary of their reports is given in the following table:

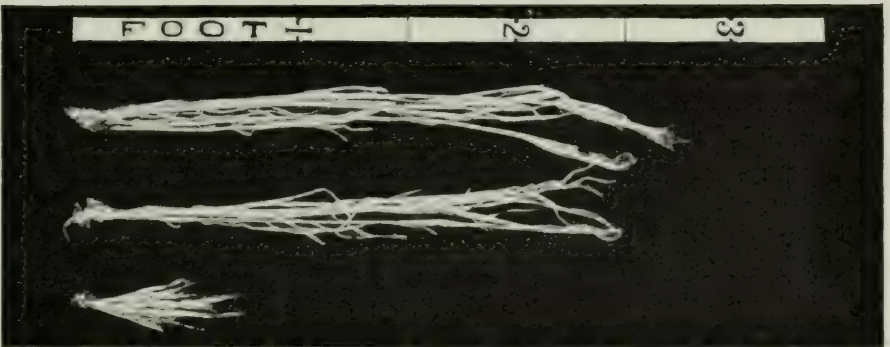
TABLE I.—Table showing difference in dates of seeding drained and undrained land as reported by 26 farmers who have drained:

Difference in Seeding Time.	Number reporting each Difference.	Per cent.
1 to 2 weeks.	5 out of 26	19.2
2 to 3 weeks.	4 out of 26.	15.4
3 weeks or over.	17 out of 26.	65.4
4 weeks or over.	13 out of 26.	50.0
5 weeks or over.	8 out of 26.	30.8
6 weeks or over.	6 out of 26.	23.1
A whole season.	4 out of 26.	15.4

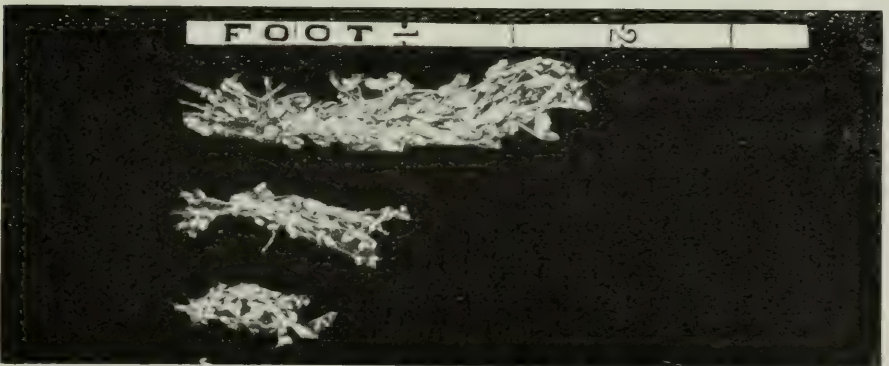
It is worthy of note that half our correspondents were able to sow their drained land four weeks or more earlier than their undrained, while nearly two-thirds of them gained three weeks or over.



3
2
1
Fig. 4. Oats on drained and undrained land.



1
2
3
Fig. 5. Barley and spring wheat on drained land, and barley on undrained.



1
2
3
Fig. 6. Peas on drained and undrained land.

Specimens sent by Mr. John McIntaggert, Brechin, Ont.

Specimens sent by Mr. Peter W. Scott, Belgrave, Huron Co.

DIFFERENCE IN GROWING CROPS.

Many of those who reported had just this spring sowed their first crop on drained land, and so were unable to give any results as to yield. These and others were asked to select average samples of growing grain from their drained and undrained fields and send them to us. They were photographed and mounted for preservation. Since harvest we again wrote the senders of samples, asking them to report on the yield of the fields from which they were chosen.

Mr. McCurdy, in commenting on his samples (Fig. 2), said: "The tall wheat, $4\frac{1}{2}$ feet high, is from drained land which would grow only swamp grass before being drained; the short one, $2\frac{1}{2}$ feet, is from undrained land. Both were sowed on September 14th, 1908, and pulled on July 3rd, 1909. Water-furrows were run through the undrained land." Reporting on the yield in September, Mr. McCurdy says the crop on the drained land yielded 30 bushels, and that on the undrained only half as much. The straw, too, was in about the same ratio, as may be seen from the figure.

The corn on the drained land (Fig. 3) was planted on May 20th, that on undrained, June 9th. Both samples were taken July 3rd.

Fig. 4 shows three samples of oats, No. 1, $2\frac{1}{2}$ feet high, from low, flat, heavy clay *sod*, drained and fall-ploughed; No. 2, 1 foot 3 inches high, from high, loamy, undrained *sod*, spring ploughed; and No. 3, 1 foot high, from high, loamy, undrained *sod*, fall ploughed. Mr. McIntaggert, in commenting on the samples, says: "Other years I was unable to work the low land till the last of seeding, but I drained it last fall, and this year it was the first land I could work. I sowed it on May 13th, while the high piece from which sample 2 was taken was not sowed till May 26th, and the other piece on June 1st."

Fig. 5 shows barley and wild goose wheat from low, flat, heavy clay, drained and fall ploughed, and barley from same kind of land undrained, and summer fallowed last year, lying right across the fence from the field which gave sample No. 1. No. 1 was sowed on May 13th, No. 2 on May 19th, and No. 3 on May 28th.

On October 18th, Mr. McIntaggert, reporting on the yields, said: "June was very dry here, and July showery, favouring the late-sown crops, for the early ones were too far advanced to benefit by the July showers; still my oats on drained land yielded 50 bushels per acre, and those on the undrained 31. As for the straw, there was not such a difference, both lands averaging about two-thirds of a ton per acre. My spring wheat on drained land was good, yielding 25 bushels per acre and a ton of straw, while that on undrained land yielded 15 bushels per acre and about two-thirds of a ton of straw. Barley on drained land yielded 50 bushels per acre and nearly a ton of straw, that on undrained 30 bushels and half a ton of straw. My crop on the drained land looked so promising that I ordered another car-load of tile and put it in this summer, so that now I have all the wet, flat part of my farm drained."

Sample No. 1, Fig. 6, peas 1 foot 9 inches high, land drained and manured, sowed May 5th; No. 2, land drained only, sowed May 5th, 11 inches high; No. 3, from land not drained, sowed April 27th, 7 inches high. The dates are worthy of note in this case, as the peas on the undrained were sowed a week and a half earlier than those on the drained,



Fig. 7. Barley on drained and undrained land. Specimens sent by Mr. H. Clare, Norwich, Oxford County.

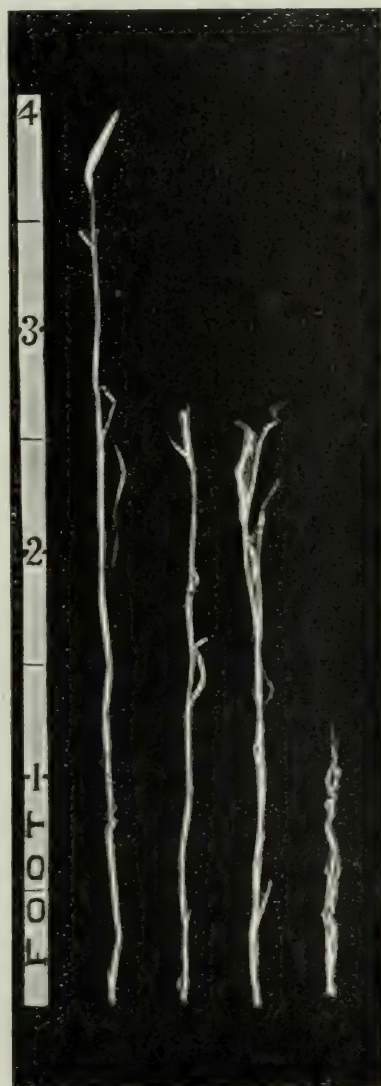


Fig. 8. Barley on drained and undrained land. Specimens sent by Mr. John A. McMahan, Petrolea, Lambton Co.

still the latter were much ahead on June 28th, when the samples were taken. Mr. Scott says there were twice as many plants on the drained as on the undrained. Reporting on yield, October 13th, he says: "On drained land the yield was 25 bushels of grain and $1\frac{1}{2}$ tons of straw; on

undrained, 15 bushels and 1 ton. The manured land gave the same yield of grain as the unmanured, but almost twice as much straw. The oats on drained land, of which I sent you a sample, yielded 50 bushels and $1\frac{3}{4}$ tons of straw, but those on the undrained gave only 10 bushels and $\frac{1}{2}$ ton of straw."

Fig. 7 shows two samples of barley, No. 1, $2\frac{1}{2}$ feet high, and No. 2, 1 foot 3 inches, or only half as high. Both were sowed on the same day, May 18th, and pulled on July 3rd.

No. 1 from the drained, and No. 2 from the undrained (Fig. 8), represent the *best samples* in the two fields. They were pulled June 28th. Nos. 3 and 4 are *average samples*, but they were pulled on June 14th, two weeks earlier than 1 and 2. The drained land was sowed on April 10th, and the undrained April 11th. Reporting on the yield later, Mr. McMahan stated that he had 15 bushels more on the drained land than on the undrained, and twice as much straw.

DIFFERENCE IN FRUIT TREES ON DRAINED AND UNDRAINED LAND.

The foregoing illustrations show in a very striking manner the superiority of grain crops grown on drained land. The difference in fruit



Fig. 9. Peach trees killed by lack of drainage, south side of flat.

trees is even more marked. In the Niagara district I recently examined a peach orchard planted in 1905, through which a broad flat extended, on either side of which the trees were large and thrifty, about 10 to 15 feet in height, I should say. In the flat, however, 12 rows were lacking, and small pear trees filled the places. In the middle of the low

land some of these were dying. The owner told me that the whole field had been planted with peaches at the same time, but that every tree in the flat had died. One or two tile drains would have made it produce just as good trees as the knolls did. Fig. 9 shows the south and Fig. 10 the north side of the flat. In the fruit belt between Hamilton and St. Catharines one may see hundreds of views similar to these.

Under-drainage will vastly increase the fruit area of Ontario, as by its aid heavy clay land becomes good fruit land. Fig. 11 shows Crawford peach trees eight years old, 16 feet apart, on heavy clay, well under-drained, on the farm of Mr. James Marshall, on the mountain, south of the city of Hamilton. Altogether there are 3,300 peach trees on the farm, some of which have now borne their eleventh crop.

DIFFERENCE IN YIELD.

Table II. shows the difference in yield for various crops on drained and undrained land as reported by our correspondents. These figures are not averages, but reports of one particular crop in each case, usually the first after the drains were put in. These men were anxious to learn if "under-drains pay," and so went to some trouble to ascertain the



Fig. 10. Peach trees killed by lack of drainage, north side of flat.

yields per acre of the first crop. Only a few mentioned the straw at all, but those who did had about twice as much from their drained as from their undrained land. After the first season it became an old story with those who had drained years ago to see these fields producing bumper crops year after year, and in only a few cases were later records kept. These few show that the advantage of the drained land continues without interruption.

TABLE II.—Difference in Yield.

Grain.	Difference in Yield.			Persons reporting.
	Drained.	Undrained.	Difference.	
Barley	30-50	0	30-50	J. H. Clare, Chapman.
Barley			20	Jos. Lapp, Cedar Grove.
Barley	50	30	20	John McIntaggart, Brechin.
Barley	40	25	15	John A. McMahan, Petrolea.
Oats	35	0	35	Wm. Bell, Washago.
Oats	40-100	0	40-100	J. H. Clare, Chapman.
Oats	50	31	19	John McIntaggart, Brechin.
Oats	80	45	35	Jas. Marshall, Hamilton.
Oats	50	10	40	Peter W. Scott, Belgrave.
Oats	50	35	15	J. E. Tovey, Perth.
Peas	25	15	10	Peter W. Scott, Belgrave.
Wheat, Fall...	45	25	20	Jas. Clayton, Cedar Springs.
Wheat, Fall...			30	R. H. McCurdy, Vienna.
Wheat, Fall...	45	25	20	Jas. Marshall, Hamilton.
Wheat, Spring	25	15	10	John McIntaggart, Brechin.
Straw			About doubled.	Several correspondents.
Hay	2-3 tons	0	2-3 tons	J. H. Clare, Chapman.
Corn	80	56	24	T. S. Biggar, Walkerville.
Corn			15-20	W. J. Dolson, Chatham.
Corn			*33%	Jas. Martin, Amherstburg.
Corn			*33%	J. B. Rhodes, Chatham.
Corn			*3	W. H. Winter, Chatham.
Beans	38	3	35	Jas. Clayton, Cedar Springs.

* 33%=about 20 bushels per acre.

VALUE OF INCREASE IN CROPS.

The following quotations taken from daily papers one day in October represent fairly well the prices this year: Wheat, \$1.00; barley, 58 cents; oats, 47 cents; peas, 90 cents; corn, 75 cents; hay in Toronto, \$16 to \$20 a ton; in Guelph, \$14.50; straw in Toronto, \$8; in Guelph, \$8. If the reader will compute the value of the increases, allowing a gain of half a ton of straw per acre, he will find it to range from \$11.05 to \$36.25 per acre, the average being \$21.65, not counting the beans, which do not constitute a general farming crop. That is, each acre drained on the farms of these men has produced at this year's prices, \$21.65 more than if it had not been drained. The average will rise or fall with the market.

UNDER-DRAINAGE AS AN INVESTMENT.

Drainage as an investment has been touched indirectly in the quotations already given. Some have stated that their drains paid for themselves in one year, some in two years. Even where the drains were put less than two rods apart and the cost ran up to \$40 an acre, they paid for themselves in two crops. Has the farmer any other place where he can invest his money and have the principal returned to him every year, or

every two years? But, says someone rendered poor and kept so by the wetness of his land, we haven't the principal, and how can we invest it? For such cases the Province has long since made provision in the Tile, Stone and Timber Drainage Act (R.S.O., 1897, chapter 41; revised in chapter 22, 9 Edward VII., 1909), by which any township is authorized to borrow money from the Province to lend to farmers for under-drainage purposes. When an individual wishes to borrow money in this way he applies to the township council, and if they approve of the loan to him they pass the necessary by-law, if one has not already been passed, and issue debentures which the Province buys from the Consolidated Revenue Fund, and lend the money to the applicant, who pays it back on



Fig. 11. Crawford peach trees, eight years old, sixteen feet apart, on heavy clay, well underdrained, on Mr. James Marshall's farm, on the mountain south of Hamilton. Picture taken July, 1908.

the instalment plan, \$7.36 per year for twenty years on every \$100 borrowed. Now tile drainage to-day costs about \$14 to \$40 an acre, depending on depth, distance apart, size and price of tile, kind of digging, etc., say \$25 average; hence the sum of \$100 would drain about four acres, and if borrowed under this Act, the total annual payment would be only \$7.36, or \$1.84 an acre, while, as pointed out above, the annual increase in crop reported by men who have put in drains is worth \$11 to \$36 an acre. Surely a man is safe in borrowing \$1.84 to get back \$11 to \$36? Surely that's a good investment? Surely even the poorest "can afford to under-drain" with this assistance. The writer knows of at least

one man who, with very little capital, bought a large wet farm under heavy mortgage, and at once under-drained it with money borrowed under the Tile, Stone and Timber Drainage Act. To-day he is well off, and still not much beyond his prime.

DRAINED LAND EASIER TO WORK.

Aside entirely from the increase in crops, there are other matters that must enter into the consideration of drainage as an investment. For instance, drained land is more easily worked than undrained. All soils contain a certain amount of cementing materials, and the closer together the particles are the more strongly the cements act, just as a postage stamp pressed tightly to the envelope adheres more firmly than one put on loosely. Undrained soil is much more compact than the drained, and therefore its particles are more firmly cemented together, hence when it dries it bakes, so that it is almost impossible to plough it, and even if it can be ploughed, it breaks up in lumps that defy the harrow, disc and cultivator, and sometimes even the roller, so that whether wet or dry it is stiff, stubborn and hard to till. Drained land, however, whether naturally or artificially drained, is the opposite; it is loosely cemented, does not bake so hard, and crumbles readily into a fine seed bed under even a light implement like the harrow. During seeding time, when even hours are precious, this is a very important consideration, for tillage costs money.

DRAINED LAND IS EASIER ON MACHINERY.

Then again, the old-time deep water-furrow is unnecessary on drained land, and the implements, instead of trundling over lumpy, hard-baked earth, and every now and then dropping into one of these nerve-straining, body-bruising, machine-racking furrows, and almost stopping at every drop, move steadily forward on smooth ground that is soft and yielding. As a horse will last longer on a soft clay than on hard city streets, so will machinery last longer on drained than on undrained land.

HOW UNDER-DRAINS PRODUCE SUCH GREAT RESULTS.

It will be of interest to consider next the principles that underly the practical results above noted.

MORE AIR IN DRAINED SOIL.

What are the physical differences between a drained and an undrained soil? First of all, the drained soil is the more porous, a fact which any farmer can prove for himself. Let him take a cubic foot of soil from drained land, and also a cubic foot of the same kind of soil from undrained land, and dry the two samples completely and then weigh them. He will find the drained to be much the lighter, and consequently it must contain much more pore space, a very important fact, for a porous soil with drains below gives a ready escape for excess water, and air follows into the soil and aids the germination of seeds and the growth of plants, for air about

the roots is just as essential to the life of plants as air in the lungs is to the life of man. A compact soil, on the other hand, retards such downward escape of water, and the soil becomes saturated, its particles run together even more closely than before, and the excess water flows away over the surface or lies in ponds till dried by evaporation.

BETTER VENTILATION IN DRAINED SOIL.

In the meantime air is almost entirely excluded, for the pores are full of water, and neither germination nor plant growth can proceed in a healthy manner, because this small amount of air soon becomes impure, since the roots give off poisonous substances, and the exchange of impure for fresh air is slow, owing to the minuteness of the pores. But the ventilation of the drained soil with its larger pores is much more rapid and the soil air much more pure.

MORE WATER IN DRAINED SOIL.

But there is another important result of the increased porosity that drainage gives; a drained soil, when ready to work, has more water in it for the crops than an undrained when it is ready to work. Strange as this may at first appear, it seems quite natural on second thought, for there's more room for water, more pore space in the drained soil. By actual test of a sample of loam brought in from the field, and one part packed like undrained soil, and the other left loose and porous like drained soil, I have found the latter, after being saturated and allowed to drain, to retain 28 per cent. more water than the former after being treated in the same manner. We must conclude that between drained and undrained land the difference in water-retaining power is somewhat similar. Let us see what this means: Loams, compact, have been proven to retain, after saturation and drainage, from four to five inches of water in the first foot of soil (they are about 50 per cent. pore space), and nearly as much in the second and third. Twenty-eight per cent. of four inches amounts to 1.12 inches, hence drainage, by rendering a loam more porous, makes it retain about one inch more of water in each foot of soil; and if the drains are three feet deep, this would mean three inches more of water than if the soil was not drained. Now at Guelph the average rainfall for the summer months is as follows: April, 1.57 inches; May, 2.30; June, 2.94; July, 2.96; August, 2.18; September, 2.21; not three inches for any month, and in no place in Ontario does the monthly precipitation much exceed three inches, hence the water saved in the soil by drainage three feet deep is about equivalent to one month's rain. And this difference is maintained as late in the season as there is sufficient rain to saturate the soil, and a similar saving occurs at every heavy shower afterward. Two things prevent rain from sinking *rapidly* into undrained soil—first, the scarcity of pore space; and, second, the air escaping upward (there's no other outlet for it); half the surface pores must be full of escaping air, while the other half are full of descending water. In drained soil the air can and does escape downward through the drains as the water presses from

above, and thus all the surface pores, instead of half, are absorbing water, and, besides, the pores are larger than in the undrained. It follows, then, quite naturally that drained land must absorb water much faster than undrained, and, therefore, that run-off and consequent loss cannot occur as early on the former as on the latter, and, therefore, that the drained land effects a considerable saving of water at every heavy shower.



Fig. 12. Pine stump with deep roots. Grew on high, well drained land.

Now, this saving and storing of water is a very important matter, as we shall see. If the reader will refer to page 15, and add the rainfall for the growing season, April to August, he will find it amounts to about 12 inches, and part of this is lost in run-off and drainage, say, three inches, leaving only nine inches for use by the crops. Tests conducted at this College have shown, however, that under our conditions ordinary field crops use, together with evaporation from the soil, from 18 to 24 inches of water. The difference between nine inches available

rainfall and the 18 to 24 inches needed indicates the amount of water that must be drawn from the great storehouse in the soil. Only when we know that the summer rainfall is only half sufficient for our crops do we realize the importance of having great quantities of water stored in the soil. Every inch of water saved and stored adds an inch for the crops in the droughts of July and August.



Fig. 13. Pine stump with shallow roots. Grew on flat, poorly drained land.

DRAINED SOIL BRINGS UP MORE WATER FROM BELOW BY CAPILLARITY.

Now the upper layers of the soil, where the roots feed, are not capable of storing enough water for the crops, even when aided by the summer rains. But deeper down in the soil, three, four, five and six feet, there are large quantities of water, which travel slowly upward and gradually reach the roots. To some this may seem a new idea, and more or less doubt may be aroused. Let the doubter take a lamp chimney, tie a piece of cheese cloth over one end, invert it, fill it with dry earth, and then set it in shallow water. He will see the water travel upward through the soil as tea will travel upward through a lump of sugar, or water through a sponge. This movement of liquids upwards

or sidewise through porous bodies is known as capillary action or capillarity. Liquids move downward by the same process, as well as by the more rapid action of gravity. And when a soil has been saturated and all the water that will has drained away, it is this same power of capillarity that holds a large amount still in the soil. The difference between the capillary retaining power of drained and undrained land has already been emphasized. And, after all, capillarity is not a new idea. From childhood we have seen coal oil lamps with the oil travelling up the porous wick by capillarity to supply the flame at the top. The same thing takes place in the soil. As the dry weather advances and the roots use up all the available water in their vicinity and call for more, as the flame calls for oil, capillarity steps in and, by slow degrees, raises a constant supply from the moister soil below, as the wick raises the oil, and so the plants thrive on into the drought. By and bye they begin to wilt and turn pale, just as a lamp flame grows dim when the supply of oil is checked. Now, drained soil has greater capillary power than the same soil undrained, because it is more porous; and, consequently, it continues to bring up water from below and keep its large plants fresh and green long after the undrained has failed to supply enough for its small ones. The reader will readily recall that in the dry weather of August the driest parts of his farm are those that in the springtime were the wettest; and, further, that the crops on these portions are the first to suffer from drought, results easily explained when he knows that these soils contain really less water when fit to till; that they bring up less by capillarity, and that they lose more by run-off, and also more by evaporation, as we shall see later.

MORE ROOT-SPACE IN DRAINED SOIL.

But there is another reason why capillary action is slower in the undrained soils. Let me illustrate: Figs. 12 and 13 represent two pine stumps, with characteristic root developments.

Those who are familiar with pine know that the deep-rooted one grew on high land, naturally well drained, while the shallow-rooted one grew on flat, wet-bottomed land; and they know, further, that where the roots go deep, as in Figure 12, the stand is much thicker than where they have to spread out laterally; and, further still, that if the land is too wet, pine will not thrive at all. The same thing occurs with grains. If sowed on well-drained land, where the water-table does not come within three or four feet of the surface except for a day or so at times of rain, the roots strike deep and strong, going down from two to four feet, as shown in Figs. 14, 15 and 16, which are reproduced by courtesy of Prof. F. H. King, of Wisconsin Agricultural College. Roughly speaking, the root development is about equal to the top, or, better, the top is about equal to the root, for the root controls. But if sowed on undrained land, where the water stands within a few inches of the surface for a month or so, the roots do not enter the water, but attempt to spread

sidewise as with the pine in Fig. 13, but the stand is too thick for that, as the drills are only eight inches apart and the seeds an inch or two apart in the drills; it follows that each plant has very little room to spread its roots, and, consequently, a small, shallow root system is developed; and this, coupled with other unfavourable conditions, produces plants that are small, sickly, and stunted. And, therefore, when the dry weather does come and the water-table recedes rapidly, owing

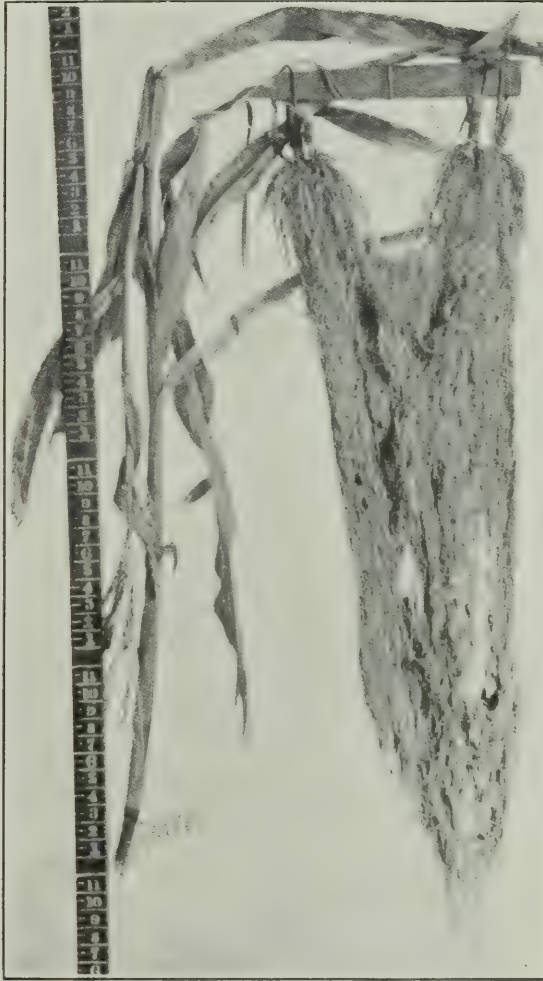


Fig. 14. Showing the total roots of one hill of corn.
Note one of the stalks, doubled beside
the measuring stick.

to evaporation, the plants are unable to recuperate and send their roots deep before the lack of water begins to be felt, and again the stunting process goes on, the roots stay near the surface, and capillarity has farther to bring water to them than it has in drained land, where the roots go down nearer the water table; and the farther it has to act the less it will deliver, just as a man pumps less water from a deep well than from a shallow one.

DRAINED SOIL IS WARMER IN SPRING.

Moreover, in the springtime a drained soil is warmer than an undrained by from 5 to 12 degrees, according to measurements made by Prof. King, of Wisconsin, a very important fact indeed, for the warmer the soil the more quickly and completely the seeds will germinate and the thriftier the young plants will be. "A good start is often half the battle" is especially true of plants.

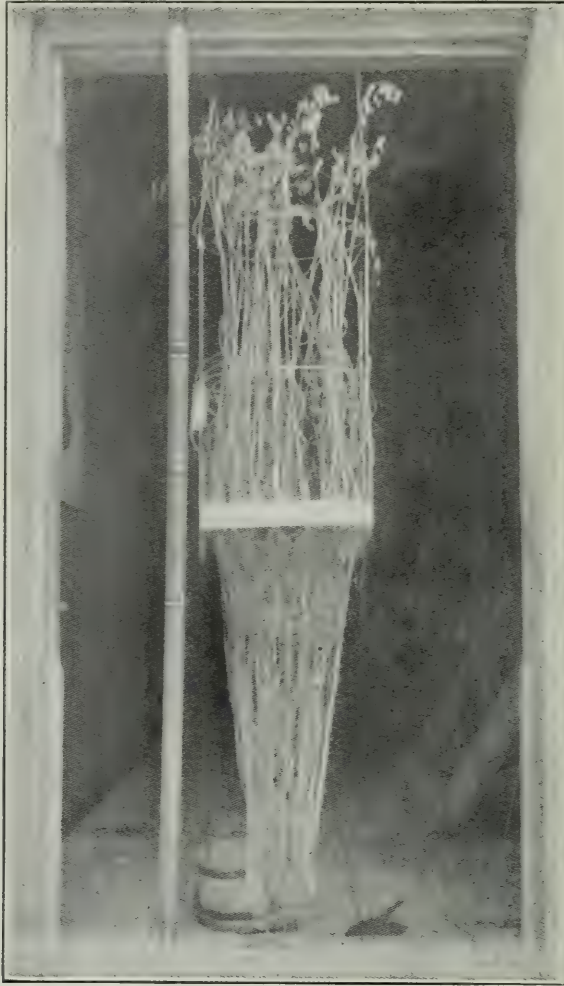


Fig. 15. Showing oats and their total roots.

The heat received from the sun is used in three ways. Some of it evaporates water from the soil, some heats the surface layers or seed bed, and the remainder is conducted to lower layers. That evaporation uses heat the reader may easily prove. Let him take two thermometers and put a dry linen or cotton gauze over the bulb of one. He will note that the two in this condition indicate the same temperature. Now, let him moisten the gauze with warm water and watch results. In a short time the wet bulb reads several degrees lower than the dry bulb, showing

that heat is being used by evaporation. As soon as the gauze becomes dry and evaporation ceases the two indicate the same temperature again. Few realize how much of the sun's heat is used in evaporating water from the soil. As long as the latter looks wet on the surface evaporation is going on about as rapidly as from free water, and the amount of heat used by it runs from 25 to 50 per cent. of the total amount received from the sun. This, at a time when warmth is needed to germinate the seeds, is a serious loss. As soon as the soil begins to look dry on the surface the rate of evaporation falls off materially, and much of the heat formerly used in turning water into vapour is available for heating the surface layers. Now, a loose, porous soil will look dry on the surface much more quickly than a compact one. Every farmer knows this, though he may not be conscious of it. After the final stroke of the harrow has been given a field, the compact soil in the teamster's foot-prints stands out dark and moist for several days after the rest of the surface is dry. Every farmer has seen this. It is often taken as an indication that rolling saves moisture, but if towards the end of the second day after harrowing the farmer will carefully scrape off the dry layer beside the foot-print he will find the soil below to be far more moist than that in or below the print itself, and he must conclude that evaporation from the loose layer has been checked, while from the compact it has continued at a rapid rate. In a similar manner, undrained soil, being the more compact, remains moist on the surface, and evaporation from it continues at full speed long after it has been checked on the porous, drained land. Moreover, loose soil is a poorer conductor of heat, and hence carries less of it down to the lower layers. The difference arising from these conditions is accentuated by another cause: Water is the hardest known substance to heat, and since during most of the time it is too wet, the undrained soil has more water in it than the drained, it follows that it must be colder. With the drained land saving heat because evaporation is checked, conducting less to the lower layers, and at the same time being easier to heat, the temperature of its seed-bed is easily maintained from 5 to 12 degrees higher than that of the undrained.

SEEDS GERMINATE BETTER IN THE DRAINED LAND.

The first, and one of the important results of this difference in temperature is that the seeds germinate better in the drained land. Every kind of seed has a temperature at which it germinates better than at any other. At too low temperatures many of the seeds will not germinate, and those that do grow very slowly. Drainage overcomes this slow, incomplete germination.

BACTERIA THRIVE BETTER IN DRAINED LAND.

From the higher temperature, coupled with the presence of more fresh air, the drained soil is superior in another way. Soil is alive with bacteria. These little organisms are to the plant what the cook is to the

family—they prepare the food, make it edible to the plant, so to speak. By their agency manure and clay and sand, which the plant cannot use as such, are changed into salts, which dissolve in water, and with it pass into the roots to sustain the plant. These bacteria need fresh air as much as plants or animals do. In the drained land there is plenty of it. Moreover, a congenial temperature is needful as much to them as to man, and this, too, they find in the drained soil. Here, then, they thrive

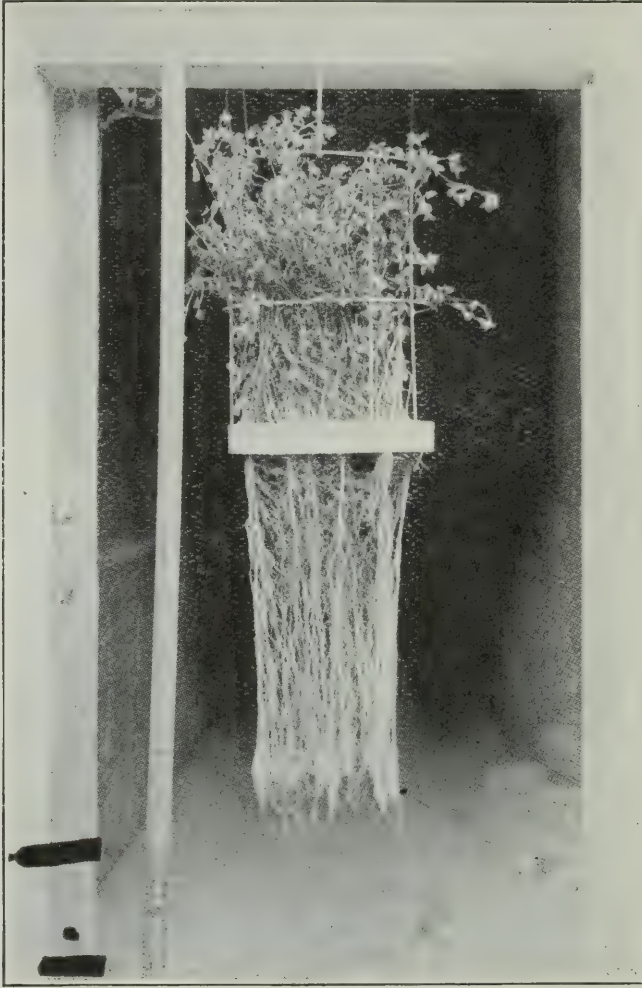


Fig. 16. Showing clover and its total roots.

and flourish, combining the elements of the air with those of the soil, and give to the plant abundance of food made to its very liking. In the undrained soil, however, the scant supply of air becomes impure, and this, with the cold, renders most of them so inactive that but little food is prepared; and one of the varieties is so constituted that when air is scarce it lives on the food already fitted for the plant.

DRAINED LAND HAS MORE PLANT FOOD THAN UNDRAINED.

From which it follows readily that the amount of plant food available in drained land far exceeds that in the undrained. And the more extensive root systems in the former enable the plants to make full use of this advantage.

RECAPITULATION.

Now, if underdrainage will move the seeding time ahead three or four weeks, if it will lessen the labour of tillage by a half, if it will give barley, peas, oats, hay and corn twice as high and twice as thick on the ground the first week in July as on undrained land in the same farm, at the same date and under the same tillage; if it will give fruit trees where otherwise they would not grow; if it will practically double the yield of grain, straw and hay; if on the average it will make every acre that is drained produce \$21.65 more than before; if it will repay the cost of drainage every year, or two years at the most, all of which our correspondents say it has done for them; if it will give ideal soil conditions for plant growth, then is it not high time that underdrainage become a general practice in all the flat, wet parts of the country, as general, forsooth, as the practice of tillage.

THE VALUE OF UNDERDRAINAGE TO THE PROVINCE.

Learning that each acre that has been drained produces on the average about \$20 more per year than undrained led us to enquire how much land is being drained annually. The Bureau of Mines, Toronto, has for many years been keeping a record of the number of tile manufactured in Ontario. From their reports we learn that the number in 1900 was 19,544,000, and that this gradually dropped to 15,000,000 in 1905, but it has risen since then to 24,800,000 in 1908. Reports for 1909, which the tile manufacturers have sent us direct, indicate that this year the output is approximately 29,000,000, or almost twice what it was when we began our drainage campaign in 1905. Is it too much to claim that, in the main, the accumulated increase in tile output since 1905 represents the benefit that the Ontario Agricultural College has been to the farmers of the Province, directly and indirectly, on this one line of farm drainage? In view of the previous falling off in drainage, we think not. If this ground is well taken, let us see the result. The accumulated increase since 1905 amounts to 27,078,000 feet of tile, which would drain about 53,178 acres more than if the rate had continued as in 1905; and the annual value of the increased crop on this area, at \$20 per acre, would be \$1,063,560.

The total number of acres drained during the years 1905-1909 is 193,436, the product of which, at \$20 increase per acre, would be worth \$3,858,720 more each year than before being drained. All these estimates are based on reports from farmers and tile manufacturers.

To gain a comprehensive view of what underdrainage may mean, we must consider the Province as a whole, and estimate what proportion of it needs drainage. As a result of careful enquiry and statements of our drainage advisors, based on examination of many sections of the Province, I have made the calculation that at least one-third of the cleared land of the Province, or 4,710,000 acres, is in urgent need of underdrainage. If that were all drained and each acre produced \$20 more than it does now, the increase in crop would be worth \$94,200,000 annually. The value of all field crops in Ontario in 1908, according to the latest report of the Bureau of Industries was \$164,077,000. Thus drainage of all the cleared land needing it might increase Ontario's field crop about 57.4 per cent. At the present rate it would take 100 years to complete the drainage.

But that does not tell the whole story of the possibilities of underdrainage. Ontario has 2,250,000 acres of slash land and 2,750,000 acres of swamp, marsh and waste land, or 5,000,000 altogether, much of which remains in this comparatively useless state only because it would be too wet for cultivation. On much of the slash and marsh a comparatively small amount of labour would do the necessary clearing, and underdrainage would reclaim the land and make it equal to the best. The swamp, too, when cleared, would yield to drainage in the same way. Thus an immense area could be added to the arable land of the Province.

CONDITIONS ON WHICH DRAINAGE SURVEYS ARE MADE.

The reader's attention has already been drawn to the fact that the Department of Physics is in the habit of making drainage surveys for those who apply for such assistance. It may not be out of place before leaving this part of the subject to state the conditions on which these surveys are made. There is no charge for the services of our drainage advisors, their salary being paid from a special drainage appropriation, but their travelling expenses, consisting of railway fare at a cent a mile each way for this work, meals on the way, if any, and cartage of instruments, if any, must be paid by the parties for whom surveys are made. They must be met at the station and returned to it, accommodated while on the job, and furnished with the necessary assistance for the work. As several surveys are usually made on one trip, the actual cash outlay for any one farmer is not likely to exceed \$2. It may be even less; or, in exceptional cases, where farmers live in remote sections, it might amount to \$5.

Those wishing surveys made should write the Department of Physics, O. A. C., Guelph, whereupon regular application forms will be sent.

CONSTRUCTION OF DRAINS.

Bulletin No. 175, on "Farm Drainage Operations," is issued as a sequel to this one, and may be had on application to the Department of Agriculture, Toronto.

Ontario Department of Agriculture.

ONTARIO AGRICULTURAL COLLEGE.

Farm Drainage Operations.

BY W. H. DAY.

The benefits of drainage have been considered in bulletin No. 174, entitled, "Farm Underdrainage: Does It Pay?" This bulletin will deal with the construction of the drains and the steps leading thereto. The first steps consist of a preliminary survey to determine the location of the drains, and a closer one to arrive at the grades, in case these are not determined in the preliminary survey.

SURVEYING INDIVIDUAL DRAINS.

Drainage problems may be divided into two classes, those involving individual drains running through well defined courses, and those involving a level area requiring systematic drainage, a drain every four rods more or less.

The individual drain is a comparatively easy proposition, and yet we find numerous examples of failure. During the past season our field men have tested drains which proved to have a fall the wrong way, and others which were given too steep a grade and consequently ran out of the ground, or at least too shallow to be continued, long before reaching the low flats in the back of the place, which were really the spots most needing drainage. In both cases the drains had to be taken up and regraded before being of any use. These mistakes arise either from unreliable methods or attempting to construct the ditch without method, i.e., "by the eye," which is almost equivalent to constructing it "by guess." It is not farmers alone who make these mistakes, for we have letters on file telling of "experienced ditchers" who failed to drain the low land at the back, although there was plenty of fall, as determined later by our levels. Where they occur with "experienced ditchers" who have methods of digging to grade, the trouble arises from "striking the wrong grade" at the start, because of not knowing the total fall. Now what

both farmers and "experienced ditchers" need in order to avoid these costly mistakes is accurate methods of determining the grade and of digging to it. Without entering into a discussion in detail of the relative

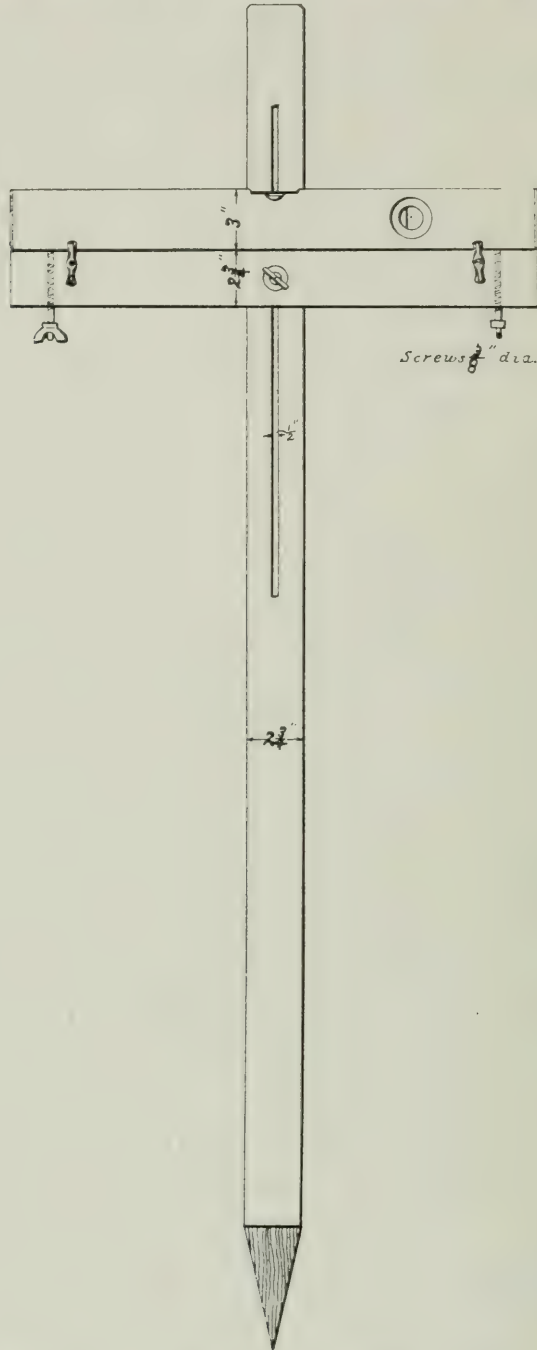


Fig. 1. Home-made drainage level.

merits of different methods, of which there are many, I will say that those to be described here are among the best known (and I think that in the large number of "experienced ditchers" whom we have met we have

encountered almost every method imaginable). The individual drain with obvious course is first staked out, then its grade determined, and, lastly, it is dug to that grade.

A HOME-MADE DRAINAGE LEVEL.

The first essential in determining the grade of a ditch is a levelling instrument of some sort adapted to determining the difference in level between two points. Fig. 1 shows the details of a home-made drainage level, which we devised some years ago, and which has proven very useful. It consists of

(1) An upright piece of wood 5.5 feet high, 3 inches wide, and 1.5 inches thick, sharpened at the bottom and shod with a long steel point, and with a slot 2.5 feet long beginning within six inches of the top.

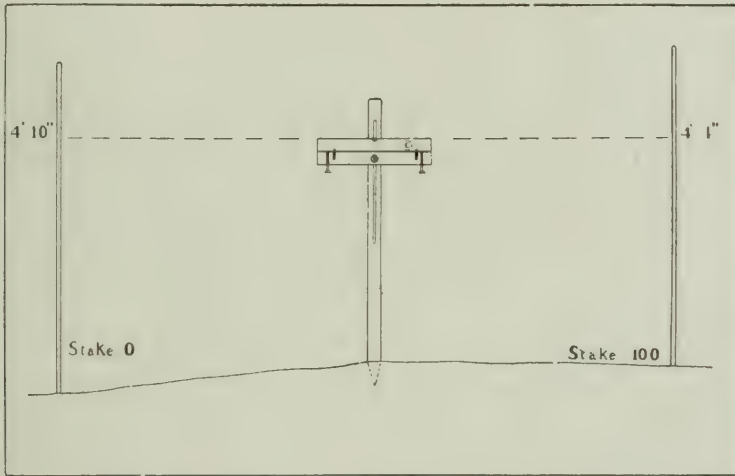


Fig. 2. Showing how to determine difference in elevation, using home-made drainage level.

(2) A cross-piece 20 inches long and $1\frac{1}{4}$ inches thick bolted to the upright by a bolt through the slot; washers at head and nut. The cross-piece may be rotated about its centre.

(3) A long carpenter's level with *straight* top sitting on the cross-piece, held loosely in position by two buttons fastened by screws to the cross-piece.

(4) Two wood screws with thumb-head, passing loosely through the cross-piece and touching the bottom of the level.

The instrument, including level, costs from \$1.50 to \$2.00, and so is within the reach of all.

DETERMINING THE FALL ALONG A DITCH.

When a man wishes to determine the fall along a proposed ditch he sets up stakes 100 feet apart from the outlet to the source, numbering them 0, 100, 200, 300, etc. He is then ready to begin taking levels. He

takes the home-made level and places it between stakes 0 and 100, as shown in Fig. 2, sinking the upright *firmly* into the ground as nearly perpendicular as possible about half way between the stakes and in line with them. If it is windy, special care should be taken to set the upright deep and firm, as otherwise it will tremble too much. He next places the level on the cross-piece and makes it horizontal by tilting and then using the thumbscrews. Two men are required to do the "levelling," A to sight and B to hold the staff (or measuring pole), and place a target (pencil or something similar) across the staff where directed. Fig. 3 shows them at work. The staff is first stood on the ground at stake 0 and A sights *backward* along the top of the level and directs B to raise



Fig. 3. Showing men taking reading with the home-made drainage level.

or lower the target until it is in line with the level, and when correct B makes a note of the number of feet and inches the target is from the ground. When this is done B moves forward to stake 100 and stands the staff on the ground there and A, without moving the level, turns around and sights *forward* to the staff, directing B as before. When the target is just level with the instrument B again notes the reading.

In Fig. 2 the back reading was 4' 10" and the foresight 4' 1". In both cases the target was level with the instrument, consequently the difference in reading must be due to the rise in the ground, and, therefore, the amount of rise must be 9 inches. The *height of the instrument* is immaterial—the *difference* between the two readings will be the same,

whether the instrument is on high or on low ground. When the rise or fall from stake 0 to stake 100 has been determined the level is next placed about half way between stakes 100 and 200, and the rise or fall between them determined in the same way. The level is next set between stakes 200 and 300, and the same operation repeated, and so on over the whole course of the ditch. When this is completed, all the rises or falls, as the case may be, are added together, giving the total rise or fall. If there are both rises and falls along the same ditch, as frequently occurs where a knoll or a hollow has to be crossed, the difference between the sum of the rises and the sum of the falls will give the net rise or fall. And when this is known, and also the length of the drain, it is an easy matter to find the rise or fall per rod or per 100 feet. And this enables one to decide whether he has fall enough for underdrainage. The fall in the ground surface however, is not always a test of whether a man can underdrain, for he may put his drains deeper at the outlet than at the source and thus have more fall in the ditch bottom than on the surface. This we often find it necessary to do.

As in determining the rise or fall along a proposed ditch there are numerous readings, which a man cannot "carry in his head," it is necessary to have some little book in which to note them. We find it convenient to use the form shown in table I, which gives the field notes on drain No. 1 in a certain survey:

TABLE I.—NOTES ON DRAIN NO. I.

Stake.	Back Sight.		Fore Sight.		Fall.		Rise.		Elevation.	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
0	4	10	.....	.....	.....	.....	.....	.....	10	0
100	5	2	4	1	.....	.....	0	9	10	9
200	5	3	3	11	.....	.....	1	3	12	0
300	5	0	3	9	.....	.....	1	6	13	6
400	4	6	4	0	.....	.....	1	0	14	6
500	4	7	4	3	.....	.....	0	3	14	9
600	4	5	4	5	.....	.....	0	2	14	11
700	4	7	4	8	0	3	.....	.....	14	8
800	.....	.....	5	3	0	8	.....	.....	14	0

Note that in six out of the eight hundred feet sections there were rises, in the other two there were falls. The six rises total 4 feet 11 inches, and the two falls total 11 inches, hence, on the whole there was a net rise of 4 feet from stake 0 to stake 800.

The last column, "Elevation," needs a word of explanation. In comparing the altitude of different places, we use the sea-level as a datum plane, *i.e.*, a given level of comparison. Toronto Bay is 250 feet, the Agricultural College at Guelph 1,150 feet "above the sea," from which we learn by subtraction that the College is 900 feet above the Bay. In a similar way we compare the elevations for different points along a ditch,

but in surveying the latter we cannot use the sea as a datum, for we do not know how much stake 0 is above the sea, hence we must choose an arbitrary datum.

In the example given we have chosen it ten feet below the ground surface at stake 0. Then the elevation of the surface above this datum plane at stake 0 is 10 feet. Since there is a rise of 9 inches to stake 100, its elevation will be 10 feet 9 inches, and so on with all other stakes. To find the rise from any one stake to any other, we have only to subtract the elevations as given in the last column. For instance, the rise from stake 0 to stake 800 is 14 feet, minus 10 feet, equalling 4 feet, the same as we obtained by subtracting the total falls from the total rises. Thus the last column, while not absolutely essential, is the most convenient means of comparing any one station with any other. If starting our survey at the source instead of at the outlet, we would choose for the elevation of the starting point some height greater than the total fall to the outlet.

DIFFICULTIES IN USING HOME-MADE DRAINAGE LEVEL.

The home-made drainage level is simple and the method of using it is simple, yet we find that many have trouble with it because: (1) They are not trained in sighting, and it is difficult for some to sight accurately along a straight-edge; (2) On a warm day there is a sort of blur when one sights over a spirit level. The sun beating down on the level heats it, and it in turn then heats the air, which is thus made less dense, "thinner" we would say, using a colloquial term, than the air beyond the ends of the level, and for a short distance above the level the layers (?) of air vary in density with the height, so that the rays of light coming from the target to the eye are bent—refracted, to use the technical term—in passing from the dense air at the end to the "thin" air of varying density over the level, and consequently we think the target higher up than it really is, and thus get a false reading. We are all familiar with refraction; even the youngest school-boy has put a stick in a pail of water, or maybe a pond, and wondered why the stick was "bent." The rays of light coming from the submerged part of the stick are refracted or bent in passing from the dense water to the less dense air, making the stick appear too high in the water. Mirages, so common in the West, are due to refraction—the light passing through air of varying density makes distant objects appear suspended in the sky. Similarly the light from the target in passing from the dense air to that less dense and less uniform in density is refracted, giving a false reading. The trouble may be overcome in a measure by sighting along the corner of the level instead of over the top, but even then it is very difficult to eliminate the error entirely, and very hard on the eyes, both of which those who have tried to sight over a spirit level on a hot day know full well.

DRAINAGE PEEP SIGHTS FOR USE ON SPIRIT LEVEL.

Since the home-made drainage level was first described we have been striving to devise a simple set of peep sights that would overcome these difficulties, and we have now succeeded.

Fig. 4 shows a pair of them. The chief point to note is that each has a peep-hole and a cross-wire. When in use they are clamped on the spirit level so that the peep-hole of one is opposite the cross-wire of the other. With them the line of sight is raised sufficiently above the level to avoid the error of refraction, and the most inexperienced can sight accurately, as looking through the peep-hole it is very easy to tell when the target is in line with the wire. Fig. 5 shows the sight clamped in proper position on the end of a spirit level. The body of the sight is made out of one piece of sheet brass bent into the shape shown in the figure. It is punched and drilled as required, the wire soldered in, and a nut soldered on one end for the set screw. At first we hoped they were so

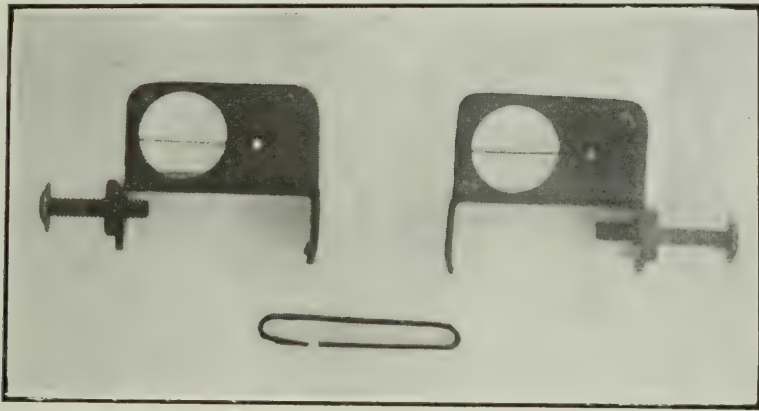


Fig. 4. A pair of drainage peep-sights, and keeper for fastening the sights together.

simple that farmers might have their tinsmiths make them up. Every set we made was correct on first trial, but, after testing with our surveyor's level several sets made by tinsmiths, we found that it was a pretty difficult thing for them, not understanding the value of absolute accuracy, to get the two peep-holes and the two cross-wires all exactly the same height, and that a small variation made a considerable error in the readings and that therefore it was necessary to have every set tested, and corrected if in error, before they could be relied on. Convinced, however, that the sights would be of great practical value to those wishing to do drainage work, I submitted the idea to a firm which has facilities for making the sights accurately and testing them, and they consented to make a small trial lot, and, if the demand is sufficient, to make more and keep them in stock for sale.

As these sights must often be carried about in the pocket when not in use, and as the cross-wires are very fine and therefore somewhat frail, it



Fig. 5. Peep-sight properly clamped on level



Fig. 6. A pair of peep-sights clamped face to face.

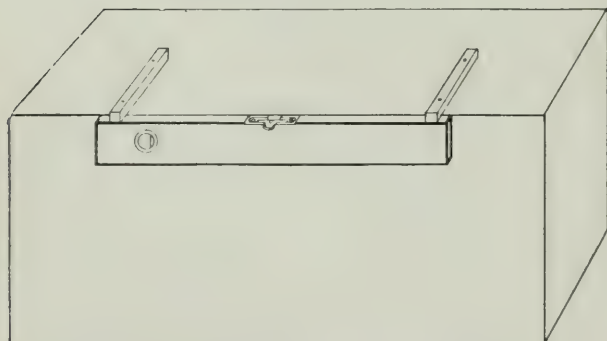


Fig. 7. Truing a spirit level by its top.

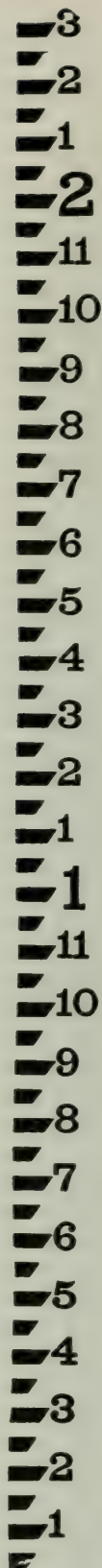


Fig. 8. Lower portion of staff or measuring stick, showing feet and inches. (Reduced.)

was necessary to devise some simple means by which the latter might be protected. Fig. 6 shows the two sights clamped face to face by a small brass keeper. In this position the wires are absolutely protected and the sights may be conveniently carried in the pocket.

By actual test with a surveyor's level we know that this simple outfit, consisting of the cross, the spirit level and the sights, used as directed, is accurate enough for all practical purposes, and that with it a man can readily decide whether he has fall enough for underdrainage by determining the grade per 100 feet; and he can also use the same instrument in digging his drain true to grade, as we shall see later.

At this point it might be well to remark that a dark lead pencil or anything dark makes a poor target for use either with or without the sights. Something pure white is much better, and for a simple reason; both the level and the wire are dark in color and the white target gives more contrast, and is, therefore, more easily seen, more accurate—and easier on the eyes as well. A little strip of wood $\frac{1}{8}$ to $\frac{1}{4}$ inch thick painted white, or white cardboard, either of which may be carried in the vest pocket, makes a splendid target. We make ours about six inches long and one-half inch wide for half its length, and an inch wide for the remainder. The narrow end is used when sighting short distances, up to 50 feet, and the wide end for a longer distances. We also cut a slot up the centre of the target for use with the sights and note the reading through this slot. When the sights are used this is more correct than reading the top or bottom of the target.

LIMITATIONS OF THE SPIRIT LEVEL.

With the sights distances of 150 feet on either side of the level can be read accurately, and if a wider target were used greater distances still might be read. But here comes in another difficulty; one cannot be certain when the spirit level is absolutely level, for it has no graduations on the glass by which one can tell when the bubble is exactly centred. By frequently testing spirit levels with a surveyor's instrument over various distances we know they cannot be relied on for more than 50 feet each way, and we advise against using the homemade level over greater distances than 50 feet. I have just measured a spirit level with calipers fine enough to read 1-256 of an inch, and find that one end of the wood is deeper than the other by 1-64 of an inch. I supposed both ends of the wood did not season quite the same, but I found the brasses on the two ends differed by the same amount, so that the error is probably one of manufacture. The level is 2 feet long, so that 100 feet equals 50 lengths of the level; therefore, the error due to the level itself in 100 feet is 50-64, or pretty nearly 5-6 of an inch. In 200 feet there would be 1 2-3 inches of error, which is becoming rather too large. Hence the level should not be used over more than 100 feet—that is, 50 feet on each side. In using the spirit level for drainage work the ends should be reversed every 100 feet; then if there is any constant error in it, half of the errors will be in one direction and half in the other, and these will balance, making the net

result correct. If the level I have just referred to were only one foot long, instead of two, then the error in 100 feet would be twice as much, or 1 2-3 inches; hence in buying a level for drainage work one should get it as long as possible, for the longer it is the less likelihood of large error.

HOW TO TEST AND TRUE A SPIRIT LEVEL.

To test a spirit level to see if it is correct one should place it on a table and if not level put a very thin wedge or paper under the lower end and build it up till the bubble is centred. Then mark with a lead pencil the exact spot the level is sitting on, and then reverse the level, placing it back in exactly the same spot. If the bubble does not centre now the level is wrong. Many levels are made so that one end of the glass may be raised or lowered by a screw which is located under the brass cap at one end of the glass. If the level is wrong this cap should be removed and the error *half* corrected, as nearly as may be, by turning the screw. When this is done the level is built up or lowered on one end until the bubble centres again. Then it is reversed once more for another test, and if there is still error, another adjustment made, then another test, and so on till it is correct. Before tampering with a level, however, one should be very sure it is wrong, and in the adjusting and testing great care should be exercised.

By the method just described the level is trued from the bottom, but in drainage work it is the *top* of the level we are using and hence it should be tested and trued by the top. To do this we tack two strips of board to a box, table, or bench, letting them project past the edge about the thickness of the level, the strips being almost the length of the level apart. When this is done the level is held with its top against the bottom of the strips. Fig. 7 shows the position. Should one end be too low a thin wedge is inserted between the strip and the table and pressed in, raising the strip till the bubble centres. Then the level is reversed, and if the bubble centres again the top of the level is correct, but if it does not centre it is not correct and the brass cap should be removed and the end of the glass raised or lowered enough to correct *half* the error. The wedge should be withdrawn or driven in as the case may be to correct the other half. If the *half* has been struck exactly the bubble will now centre when the level is reversed. If the *half* has not been struck exactly there will still be a small error and this should be corrected in the same way, and another test made. When the bubble centres, no matter which way the level is placed, then the top is correct with the glass, and very accurate work can be done with it. We would strongly recommend the testing and adjusting of levels in this way when intended to be used for drainage work. Great care and accuracy should be exercised in the adjusting.

The level previously mentioned which was 1-64 inch out in depth of the two ends was tested and trued in this way so that the top was correct, and when used with the peep sights and checked with the sur-

veyor's level was found to be accurate within $\frac{1}{8}$ to $\frac{1}{4}$ of an inch over 100 feet, that is 50 feet on either side.

We have already mentioned that many of the spirit levels have no graduations on the glass and consequently it is difficult to tell when the bubble is exactly centred. With such we have found it a good plan to take a new file with sharp corners (not a three-cornered one) and after removing the brass plate make two scratches across the glass the proper distance apart and then true the level by these scratches in the manner above described. Without these marks it is impossible to true a level with any degree of accuracy.

Of course if the level is not an adjustable one it cannot be trued, and must be used as it is whether correct or not, or else discarded and another procured.

THE STAFF OR MEASURING STICK.

No elaborate staff is needed with this outfit. A strip of clear pine board six or eight feet long with the feet and inches marked on it does nicely. Some of the manufacturers of surveying outfits have very heavy white tapes $1\frac{1}{4}$ inches wide with the feet and inches marked on them in heavy black figures and lines, especially made for this work. Fig 8 shows a piece of one of them.

When in use they are tacked to a strip of board $1\frac{1}{4}$ inches wide, and when not in use they may be rolled up and put away. They cost from 60 cents to \$1.50, depending on length, quality, etc.

DETERMINING THE GRADE OF THE DITCH.

From the elevations determined in finding the fall along the ditch a profile may be made and the grade worked out. The different steps in making a profile may be performed as follows:

(1.) Procure a piece of cross-section paper similar to Fig. 9, on following page. It is ruled in large squares one inch to the side, and these again into small squares one-tenth or one-twelfth of an inch to the side. This can be obtained from any bookseller at five to ten cents a sheet 15x20 inches in size. If cross-section paper is not at hand, a large sheet of foolscap may be ruled with light upright lines and made to answer well. For clearness of reproduction some of the vertical lines have been omitted from the profile shown in Fig. 10.

(2.) Let elevations be measured *up and down* on the paper, and distances between stakes be measured *right and left*. The datum plane or level of comparison will then be at the bottom of the paper, and stake 0 at the left hand side. If, however, the elevations were large, it would require a very big piece of paper to show the ground surface and also the datum plane; hence it is customary in such cases to show some other horizontal plane a few feet lower than the lowest point along the ditch, e.g., if the lowest elevation were 40 feet, the 30-foot level would be shown where the datum plane is in Fig. 10.

(3.) Let one large square up and down equal two feet of elevation.

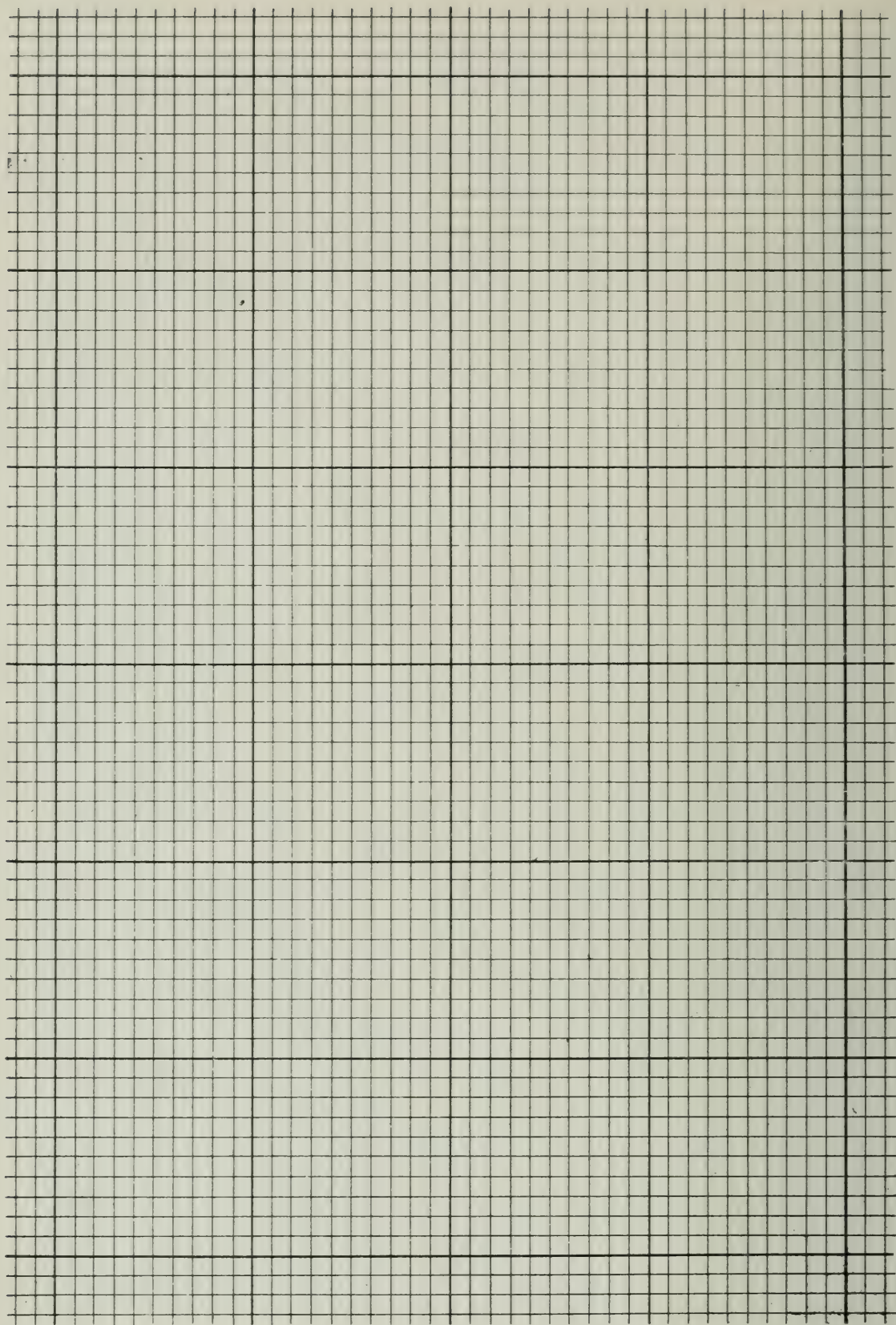


Fig. 9. Cross-section paper: It may be obtained with lines light green, light blue or orange, the green or blue being probably the better.

(4.) Let one large square right and left equal 100 feet from stake to stake.

(5.) Number the stakes along the datum plane as shown in Fig. 10.

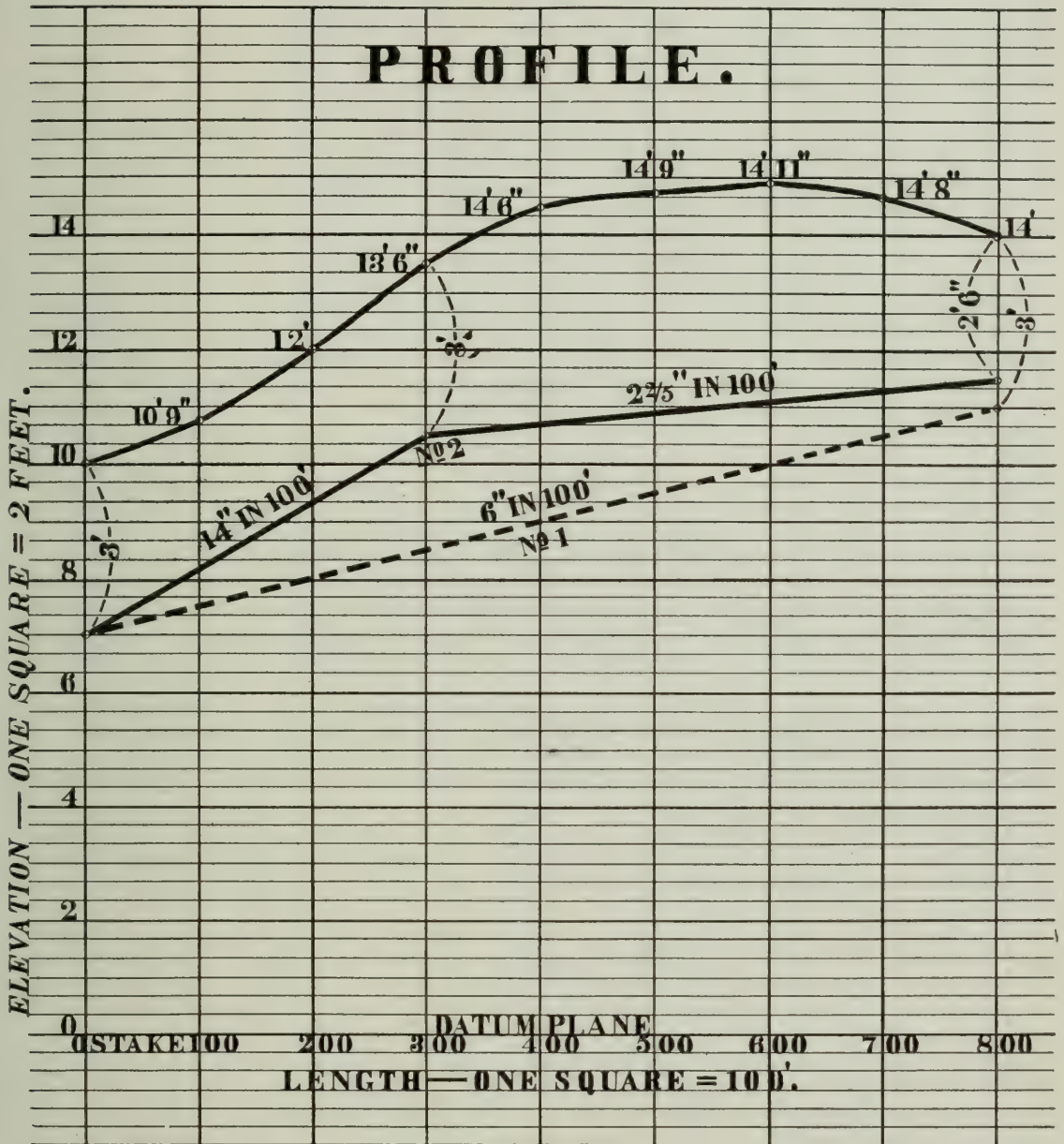


Fig. 10. Profile of drain, illustrating method of determining the grade or grades of the ditch bottom.

(6.) At each stake make a dot the proper distance above the datum plane, showing the elevation at that stake, *e.g.*, at stake 0 in the figure a dot is made 10 feet, *i.e.*, 5 squares, above the datum; at stake 100 a dot is made 10 feet 9 inches, *i.e.*, 5 $\frac{3}{4}$ squares above the datum; at stake 200 a dot

is made 12 feet above the datum; and so on, the proper elevation at each stake being marked by a dot. These figures are taken from the field notes already given, page 5.

(7.) Join all these dots by a line. This gives the shape of the ground surface from source to outlet, or the "lay of the land," as one farmer expressed it, from stake 0 to stake 800, showing at a glance just where the fall is slow or rapid.

(8.) At stake 0 make a dot as far below the ground surface as the ditch is to be deep at the outlet. This is determined by the nature of the outlet, and is always known; let us suppose it is three feet in this case, (that would equal a square and a half on the paper); hence we make a dot at 7 feet, for the ground surface is at 10 feet.

(9.) Then at the other end of the ditch, stake 800 in this case, make a dot below the ground surface, showing the depth there. The depth at the source is usually a matter of choice. In this case let us choose 3 feet as a trial depth. Then the dot would be made at 11 feet, for the ground surface is at 14 feet.

(10.) Lay a ruler on the paper and draw a very light line joining the two dots at the end—see dotted line No. 1 in Fig. 10. This line will show where the ditch bottom would run if the ditch were dug at uniform grade and made 3 feet deep at both ends. By counting the number of spaces between this dotted line and the ground surface at any point, the depth of the ditch can be learned. Applying this test, we see that the ditch shown in the figure would be four feet deep or more throughout most of its length, if ditch bottom No. 1 were used, and that it would be five feet or more for over half its length, in some places being $5\frac{1}{2}$ feet. Hence we conclude that it is not advisable to dig this ditch three feet deep at both ends and of uniform grade, if it can be avoided—there is too much digging.

Whether it can be avoided or not depends upon the amount of fall from stake 800 to stake 0. The fall is 4 feet, which is equivalent to a grade of 6 inches in 100 feet. Now this is much steeper than is absolutely essential for effective drainage. The minimum grade for safety with small tile is about 2 inches in 100 feet. A drain to be *safe* must have grade enough to give the water a *velocity sufficient to move any sand* that may enter at the joints of the tile. Two inches in 100 feet in 3 or 4 inch tile will give that velocity and a little to spare. Many tile drains laid on slower grades than this have done and are doing good service, but where there is any possibility of coarse sand entering the tile, they are within the danger zone. On the same grade water runs faster in large tile than in small ones, for instance, in 12 inch tile it runs a shade more than twice as fast as in a 3 inch, and consequently large tile may safely be laid on a slower grade than small ones.

Then, coming back to our problem, we see that we have plenty of fall, hence we can dig the upper section of the drain to a slow grade, and the lower section to a steep grade. As we are striving to escape digging let us choose a depth of 2 feet 6 inches (instead of 3 feet) at stake 800, and

3 feet at stake 300, the depth at the outlet remaining 3 feet as before. Joining the dots made at these three places we obtain a new ditch bottom No. 2, with a change of grade at stake 300, the grade of the upper section being 2 2-5 inches in 100 feet, and of the lower section 14 inches in 100 feet. This is a much more desirable bottom than that shown by the dotted line, the deepest digging being a shade less than 4 feet, and the shallowest 2 feet 6 inches. The average saving in digging by using bottom No. 2 rather than No. 1 would be almost one foot throughout the entire length of the drain. In case the second trial did not give us a satisfactory bottom we would make still further trials till a satisfactory one was found. A similar profile may be made for any drain, once the elevations at the different stakes are known. There is one critical point in each drain, viz: the outlet; knolls and basins, where they occur, are also critical points—we must choose grades that will not require us to go too deep in the knolls nor too shallow in the basins. When striking the grades we consider first the critical points—the others will look after themselves.

(11.) To determine the grade on a section of drain when the depth is different at the two ends of the section, we proceed as follows: Subtract the elevation of the ground surface at the two ends (this gives the fall, on the surface), and then add or subtract the difference in depth, according to which end is the deeper. For example, the upper section of the drain in Fig. 10: 14 minus 13 feet 6 inches equals 6 inches, hence in the ground surface there is a fall of 6 inches; but the drain is six inches deeper at stake 300 than at the upper end, hence the fall in the ditch bottom is 6 plus 6, which equals 12 inches in 500 feet; hence the fall per 100 feet equals 12 inches divided by 5, which equals 2 2-5 inches.

With methods for finding the fall along the ditch and of determining its grade, we are ready to deal with the construction of the individual drain, but before passing to that we shall consider the more extensive and involved problem where a general survey is needed before construction is begun.

SURVEYING FOR COMPLETE DRAINAGE SYSTEMS.

To be sure many of our Ontario farmers have long had methods of laying out individual drains, and during the last few years many have adopted those just described, but when it comes to the planning of a general system for 50 or 100 acres, a system composed of several miles of drains, every part of which must fit in with every other part, the grades of which must be sufficient for effectively draining all low spots, and yet not require too deep digging in knolls, the depths of which must, nevertheless, be great enough in flats to protect the tile from frost, the outlets for which must be ample and free—when it comes to the planning of such a system, many of which are imperative in almost every county if proper drainage is to be secured, few, if any, have been or are now in a position to undertake such work intelligently, and for obvious reasons: Firstly, because some knowledge of surveying and mapping is needed, and

secondly, because a surveyor's level is essential, neither of which the farmer has. Nor until recently has he been able to obtain assistance in the matter. In the autumn of 1905, however, the department of Physics, which had for some years been teaching the subject of drainage, was authorized to go out through the Province, when farmers applied for assistance, and make a general survey of the land, locate the outlets and the drains, determine the grades and size of tile, and finally send the farmer when ready a map of his farm showing the complete system of drains, the grades, the sizes of tile, etc. It is the writer's intention to give here a brief description of the method of surveying the land and laying out the system, and a detailed description and interpretation of a map, not in the hope of enabling farmers to undertake these general surveys, for we know the work is too involved and the instruments needed too delicate

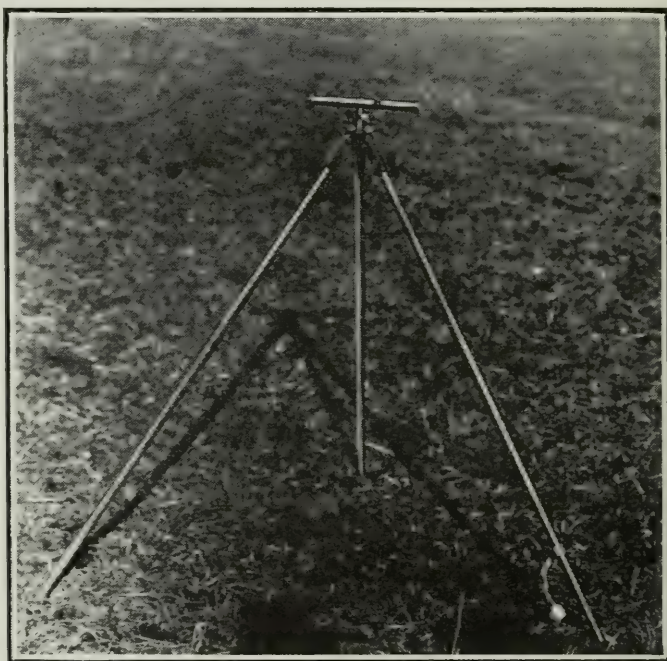


Fig. 11. Dumpy level (on tripod) used in drainage surveying.

and expensive for that, but in order that when we have made a survey for a man and sent him his map, a copy of this bulletin will enable him the better to understand the map and construct his drains according to it.

The first operation consists in taking the levels and working out the elevations every 100 feet square all over the area in question. The instrument used for this work is an ordinary dumpy level, shown in Fig. 11. The telescope is mounted on an axis and rotates horizontally so that it may be set in the centre of a block of land and readings taken in every direction all around it, instead of in only two as with the home-made level.

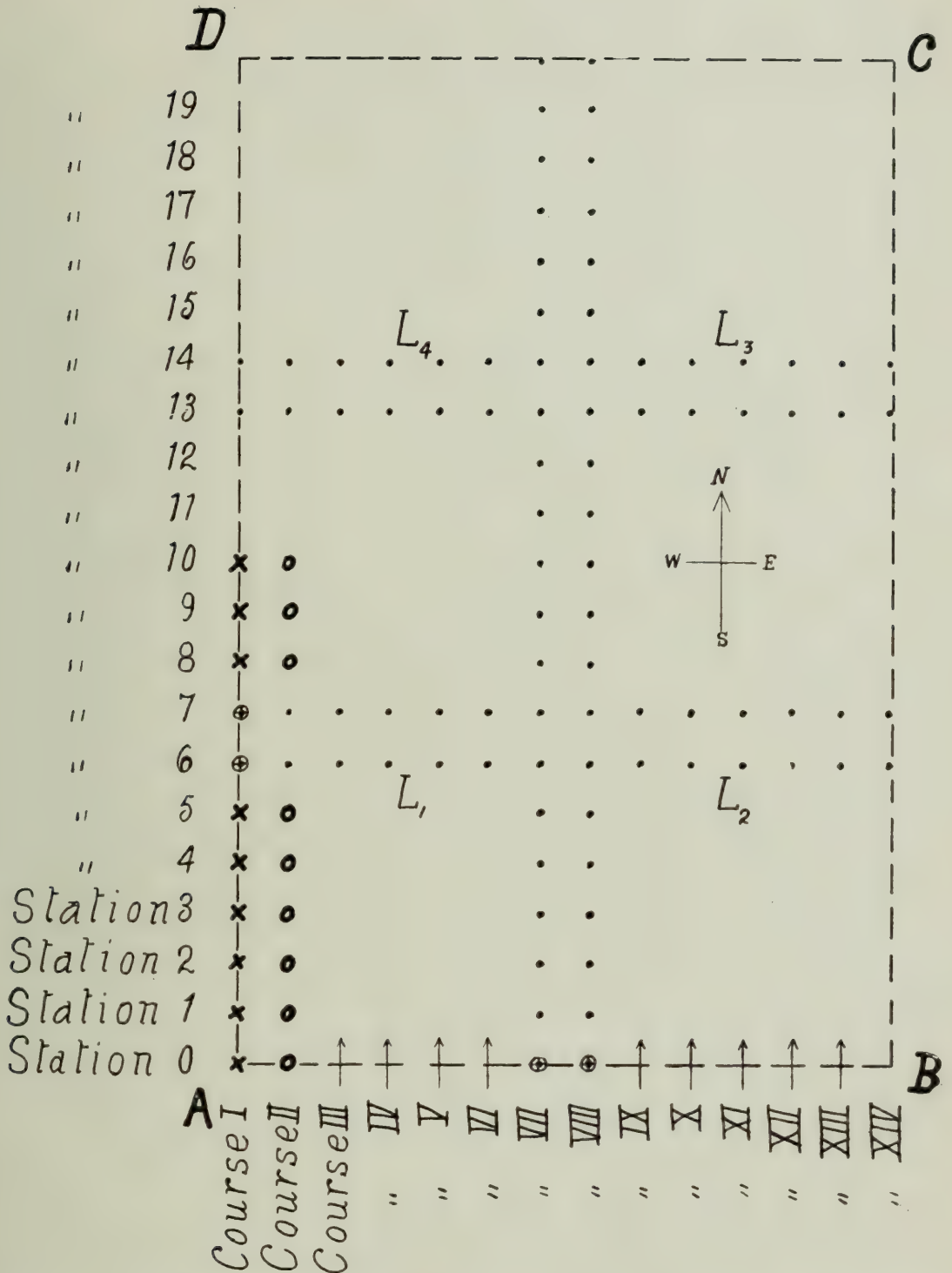


Fig. 12. A field laid out for drainage surveying—two rows of stakes 100 feet apart running through the centre of the field, and two pairs of cross rows, one near either end.

LAYING OUT THE FARM FOR LEVELING.

Now, if we are to take levels every 100 feet square we must have some method of finding those points without measuring them all, for it would mean an immense amount of labour to measure out and stake a whole farm. The method we follow may be understood by the aid of Fig 12. A B C D represents the area to be surveyed. After having walked over it in company with the owner and learned all we can about it, located the probable outlet, and formed an estimate of the probable difficulties to be encountered, we select a base line, say A D, and run two rows of stakes right down through the centre, parallel with the base line, and a full number of hundreds of feet from it, both the rows and the stakes in them being 100 feet apart. When this is done, we run a pair of cross-rows at right angles to the first two, rows and stakes being 100 feet apart as before. If the piece is so large that the cross-rows cannot be seen half way, two pairs may be needed, as shown in the figure, or even more. Lath are used for stakes where available. We make no attempt to stake out the area permanently, for in very few cases is the draining to be done immediately, and permanent stakes through the fields would be in the way in the meantime. But enough permanent stakes are set to enable the farmer to put up the rows again if necessary to locate the drains. These permanent stakes are always indicated on the map, as will be seen later.

TAKING THE LEVELS.

When the staking is done as indicated, the level is set up near one corner, say at L_1 . As with the home-made level, two men are needed, a levelman and a staffman. When the instrument is "levelled up," the staffman sets the staff on the ground in the corner of the field, *e.g.*, at A, sighting two ways, east and north in this case, and putting himself in line with stakes in two directions. When the level-reading has been taken, he moves north 100 feet from the corner, as shown by the X opposite the words "station 1," sighting himself in line both north and east as before. Another reading is taken by the levelman. The staffman then moves 100 feet farther north, as shown by the X opposite "station 2," sights himself in line in two directions, and another level is taken. He continues to travel along the course as shown by the X's, setting the staff on the ground at every station, and allowing the levelman to take a reading. When he has got as far along course 0 as the levelman can read, which usually happens at about station 10, he crosses over to station 10 of course 1, and sets the staff every 100 feet, as shown by the O's, the levelman taking a reading in each case. When he has arrived at station 0 of this course, he crosses over to station 0 of course 2, and readings are taken along it up to station 10, and so on. Back and forth over the field the staff is set at distances of 100 feet until all around the level the

stations have been read as far as the levelman can see. In case there are any marked knolls, depressions or watercourses between the 100-foot stations, readings are taken there also. The instrument is next moved to a new block and set up, *e.g.*, at L_2 . The first reading in the new block is always taken on some station already read in the old block, so that the elevations in the two may be reduced to the same datum or sea-level. When all the readings in block 2 have been taken, the instrument is moved to L_3 , and so on until the whole area has been "levelled." The levelman keeps the notes in a form similar to that given on page 5 for the home-made level, save that there is only one column for "readings" instead of two. The "elevations" are worked out for all the stations as with the individual ditch.

The levels are next taken along the outlet. Knowing what the elevations are over the area to be drained, we are in a position to tell when we have gone far enough down the outlet to get clearance for all the drains.

MAKING THE MAP.

When the elevations have all been determined, we are in a position to construct our map. Fig. 13 shows one of these maps complete. The different steps in the making of a map are as follows:

(1) We procure a piece of cross-section paper (see Fig. 9) large enough to hold a map of the survey, allowing 1 inch=100 feet, and at the corners of the squares all over the map we mark the elevations. In the map shown the small figures appearing at regular intervals over the field indicate the elevations at those points.

We are now in a position to compare the levels of different parts of the farm. For instance, the N.W. corner has an elevation of 32.7, and the N.E. corner an elevation of 17.9 feet, hence along that north side there is a fall of $32.7 \text{ minus } 17.9 = 14.6$ feet in a distance of 2,200 feet. The fall along the south side is much less, however, being only $23.3 \text{ minus } 19.8 = 3.5$ feet. If, however, we undertake to compare many of these elevations two at a time in this way, we see at once that we have an endless and confusing task.

(2) To render the comparison of elevations easy, and to show at a glance the general slope of the land, we next put in *contour lines*. They are the dotted lines curving in and out across the field. Notice the first of these on the east end of the field. It begins with an elevation of 18.0 feet on the north side, and ends with an elevation of 18.0 on the east end, and moreover every point along it has the same elevation, as may be seen by observing that when it crosses between two elevations one is a little less than 18.0, and the other a little greater, and the contour always divides the intervening distance proportionally. Now look at all the elevations to the east of the 18-foot contour—they are all less than 18 feet, and all those on the west of it are greater; hence, the low land is to the east, the high land to the west.

PLAN OF DRAINS

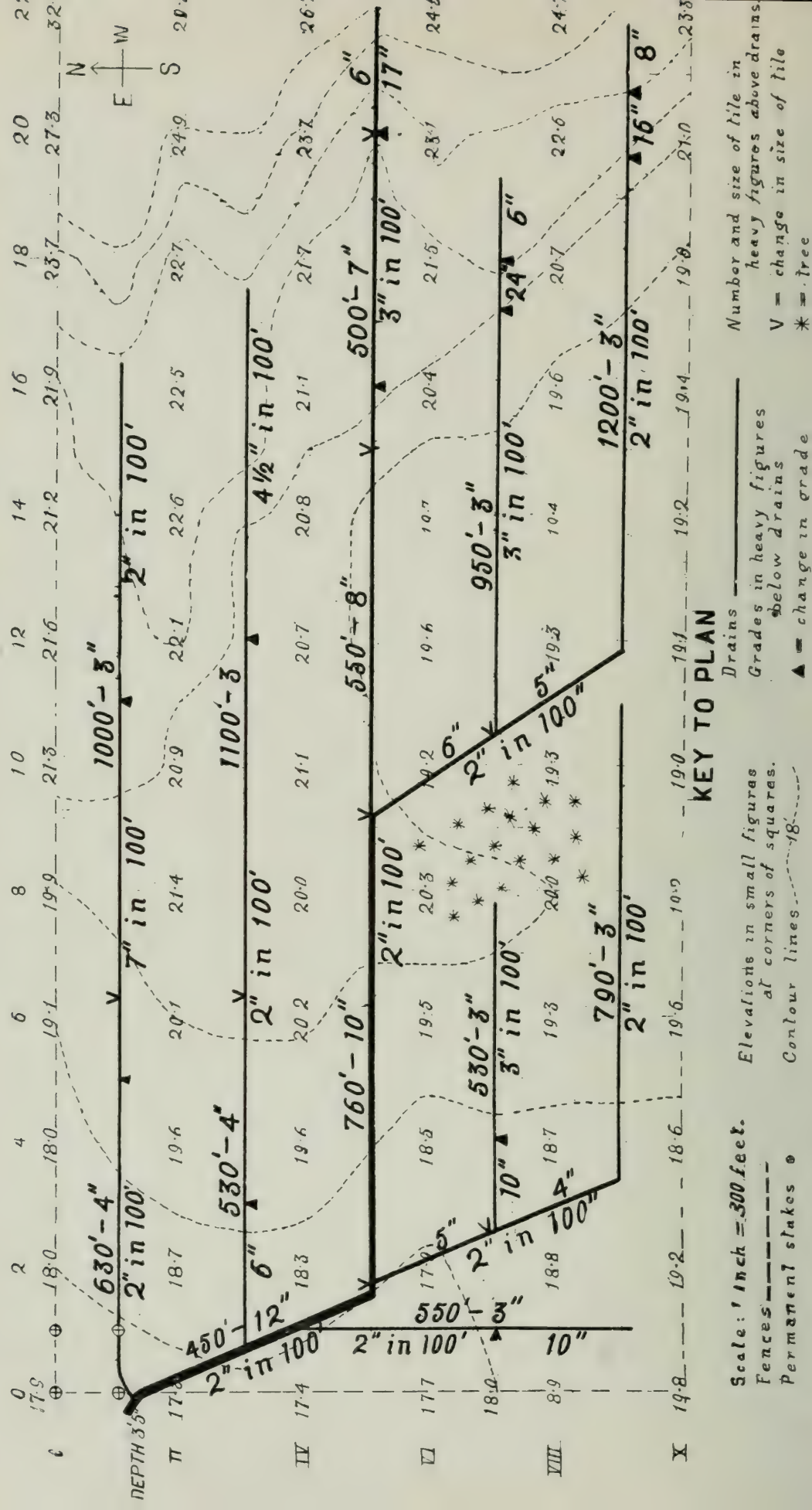


Fig. 13. Plan of drains, showing location of drains, depth at outlet, size of tile, grades, etc.

Now look at the 19-foot contour, the next dotted line to the west. Every point on it has an elevation of 19 feet, and hence there is one foot of fall from this to the 18-foot contour.

The 20-foot contour is a very irregular one, beginning at station 8 on the north side and ending at station 18 on the south side. The 21-foot contour is more regular, but also runs almost diagonally, while the others run in the same general direction.

These contours aid very materially in indicating the general slope of the land, but they show us several things specifically:

(a) The greatest fall is along the shortest distance from one contour to the next, approximately at right angles to them.

(b) When the contours are far apart and irregular, they indicate flat, level land, but when close together and regular they indicate a steeper slope.

(c) A loop of the contour toward the outlet indicates a knoll at that point.

(d) A loop away from the outlet indicates a "flat" extending backward toward the higher land, and usually indicates the position for the main drain.

(3) With the contours as a guide, we locate the main drains and the laterals, keeping the mains in the lowest land as far as possible, and the laterals at right angles to the contours as nearly as may be. At the same time we endeavour to adopt a system that gives long drains rather than short ones, as there will be fewer junctions, unless such a system is distinctly inferior in some other way. The heavy black lines in the map indicate drains. The distance apart at which drains should be placed is fully discussed on page 25.

(4) We next take the hardest spot in the whole area to drain, *i.e.*, the lowest and farthest from the outlet, and make a profile (as described on pages 11-15) from there to the outlet, using the minimum depth in the low spot, getting as much grade as possible, and yet striving to avoid too deep digging. This gives us the depths of our main throughout.

(5) The grades of the laterals are then worked out, using a profile if necessary. This can be done now, since we know the depth where they join the main and the approximate elevation of the land every 100 feet.

Wherever a change in grade occurs, the point is indicated by a solid black triangle pointing to the ditch. All grades are stated below the drain, *e.g.*, "8¼" in 100' means 8¼ inches fall in 100 feet.

(6) We next decide on the size of tile, using as a guide the table to be given later on page 24. The number and size of tile are entered above the drain, *e.g.*, 950'-4" means 950 feet of 4-inch tile. A change in size of tile is indicated by a V at that point.

(7) Each map is accompanied by a "key" explaining all the symbols used in the map. (See Key, Fig. 13.)

(8) The depth of the main at some point is always given. When

this is known, and also the grade, the main is begun at this point and constructed either up stream or down, as the case may be, and when the main is dug, the depth of each lateral at the junction is known, and the laterals may be dug, beginning at the main. Let me say again, *the place to begin operations, according to one of our maps, is the point on the main where the depth is given.*

(9) If the owner wishes to know the length of any particular drain, he can find it by measuring the line on the map, for 1 inch on his paper equals 100 feet in the field.

These maps have proven of great practical value. In numerous instances the owners have gone ahead and completed the whole system in one job, while in many others a field or two is drained each year. More-



Fig. 14. A typical drainage demonstration.

over, they are retained as a record, giving all the facts about the system, so that any drain may be located if desired. When the farm is sold or handed down to the son, the map is especially valuable, as it shows the new occupant what drains there are and just where each may be found.

For these same reasons those who put in systems of drains of their own planning might do well to make a map for future reference.

DRAINAGE DEMONSTRATIONS.

At the conclusion of the survey, after the map has been worked out in the rough, a public meeting is held in the field where the survey has been made, and the methods of finding the fall, determining the grade,

digging the ditch true to grade, etc., are demonstrated. The map is examined, difficulties discussed, and details of construction dealt with, and, in fact, drainage in all its aspects is fully considered. Fig. 14 shows a typical scene at a demonstration, with an average attendance.

These demonstrations are beneficial in many ways. Besides giving much information about drainage, they are practically a public pledge of the owner to "do something," to put in some of the drains, and usually he does so at an early date; secondly, they lead the public to watch results, and the effect is sometimes remarkable. An instance was given in Bulletin 174, where within one year's time nine neighbours began under-draining as the result of one drainage demonstration. Where the movement has now reached its third and fourth years, practically whole communities are draining, *e.g.*, in the vicinity of the Horticultural Experiment Station at Jordan Harbour, Lincoln County. The station farm was drained in 1907 with eleven miles of tile, and this year there have been enough drains put in there, within a radius of five miles, to keep a traction ditcher busy all summer.

WHAT SIZE OF TILE TO USE.

In every drainage problem we are confronted with the question, "What size of tile shall we use?" a question that cannot be answered offhand. As a matter of fact, it is the last thing decided in our drainage surveys. We cannot decide it from the acreage alone, we must know the grade of the ditch, for the steeper the grade the more water will run through a tile of given diameter. For example, if we double the grade of a tile the velocity of the water is increased approximately 40 per cent., and consequently the same tile will carry 40 per cent. more water on the new grade, and consequently it is capable of draining 40 per cent. more land. Thus we see that to decide the size of tile to use in a given case we must know the acreage to be drained through the tile and also the grade. As a result of extensive scientific experiments a rule has been formed by which the size of tile can be determined when the acreage, the grade and the maximum amount of rainfall in twenty-four hours are known, but the rule and its application are too complicated and mathematical to be dealt with here. Suffice it to know that there is such a rule and that some one has been kind enough to apply it to all practicable grades and sizes of tile and tell us what acreage can be drained through each size on each grade. This information is contained in McConnell's table, which is given herewith.

TABLE II.—SIZE OF TILE PIPE OF MAIN DRAIN.

(McConnell.)

Fall.		Acres Drained.					
		3-inch tile.	4-inch tile.	6-inch tile.	8-inch tile.	10-inch tile.	12-inch tile.
1 foot in	20	18.6	26.8	74.4	150.0	270.0	426.0
1 "	30	15.1	21.8	60.4	128.0	220.8	346.0
1 "	40	12.9	18.6	51.6	108.8	189.6	298.4
1 "	50	11.9	17.0	47.7	98.0	170.4	269.0
1 "	60	10.9	15.6	43.4	90.0	156.0	246.0
1 "	70	10.0	14.5	39.9	83.0	144.4	228.1
1 "	80	9.3	13.4	37.2	77.0	135.0	213.0
1 "	90	8.1	12.6	35.0	72.5	127.0	200.5
1 "	100	7.3	11.9	33.1	69.2	120.6	190.5
1 "	150	6.7	9.5	26.6	56.0	97.3	154.4
1 "	200	5.7	8.2	22.8	48.0	83.9	132.5
1 "	250	5.1	7.5	20.4	42.4	74.4	117.0
1 "	300	4.6	6.9	18.4	38.2	65.5	107.0
1 "	400	4.1	5.9	16.5	32.6	60.3	90.7
1 "	500	3.7	5.2	14.8	30.1	54.0	81.6
1 "	600	3.3	4.7	13.3	28.0	48.6	74.0
1 "	800	2.9	4.1	11.4	24.0	41.9	65.0
1 "	1,000	2.6	3.7	10.2	21.2	37.2	56.0
1 "	1,500	2.1	3.0	8.5	16.8	30.8	47.0
1 "	2,000	1.9	2.8	7.4	15.0	25.0	40.8

Using the maximum rainfall at Guelph as a basis I have applied the rule and worked out several grades and sizes of tile, and found that the table corresponds very closely with our requirements here, and so we have adopted it in all our work.

The use of the table may be illustrated as follows: Suppose a man has 12 acres to drain and the slope of his main is 1 foot in 600, then we look down the list of falls till we find 1 foot in 600 and follow this line to the right. A 3-inch tile would not do; it drains only 3.3 acres. A 4-inch tile drains only 4.7 acres. A 5-inch tile, not given, but probably drains about 7 to 9 acres. A 6-inch tile fills the bill, as it is capable of draining 13.3 acres. The size to use for any other slope is determined in the same way. For instance, if 70 acres are to be drained on a grade of 1 foot in 100, an 8-inch tile will be necessary. The table applies to the submains and laterals as well as to the mains.

Owing to the great amount of friction in small tile compared with the volume of water they can carry, they are much more likely to clog with sediment than the larger ones, so much so indeed that a 2-inch tile should never be used except on a steep grade. In time they are almost sure to clog on a slow grade. For the same reason, the use of 2½-inch tile is not encouraged.

only one foot at X. Capillarity and soil resistance to water flow play an important part in holding the water highest half way between the drains, and the gradient 1 in 25 represents their combined strength in clay, hence after this gradient is reached drainage becomes very, very slow, and the water table stands in this irregular shape until lowered by evaporation from the soil and plants. But during the months of April, May, and sometimes June, when the rains supply at the surface all the water needed for evaporation, none is drawn from below for this purpose, hence during the early months of growth the water stands as indicated by the dotted line AXB. Consequently root development is hampered at X, as 1 foot of soil is not enough. There are two ways to remedy the defect, either to dig A and B deeper or else put a drain at C half way between. If A and B were lowered 1 foot there would then be 2 feet of drained soil at X, and 4 at A and B, or an average of 3 feet throughout the field. If a tile were put in at C the same depth as at A and B there would be 3 feet of drained soil there as well as at A and B, and 2 half way between, giving an average of $2\frac{1}{2}$ over the field. From which it would appear that the drains should be at least 3 feet deep and close enough together to give at least 2 feet of drained soil half way between. Applying the gradients 1 foot in 25 for clay and 1 in 33 for loams we see that for depths of 3 to $3\frac{1}{2}$ feet the drains should not be more than 50 to 66 feet apart in clay and 66 to 100 in loam. But this is only a general conclusion and judgment must be used in each individual case. Practical experience shows however that in heavy clays it is profitable to put the drains even as close as 25 to 30 feet.

THE CONSTRUCTION OF THE DRAIN.

When the survey either for an individual drain or for a general system has been completed, and the profile or map giving the grades is in the farmer's hands, he is in a position to begin the construction of his drains. He needn't worry much about methods of operation if an "experienced ditcher" is employed, for in the vast majority of cases these men have methods of following grades sufficiently accurate to enable them to construct any system of drains when given the initial depth and the grades. An occasional test however will be a satisfaction to him and at the same time prevent any possible tendency on the ditcher's part to shirk the grades in order to get shallower digging.

But in many cases the farmer must put in his own drains, for there are not enough ditchers to do half the ditching that is being done. For the benefit of beginners and others wishing to improve the methods they have the different operations will be discussed in detail.

USE OF PLOUGH IN DIGGING THE TRENCH.

In the spring and early summer, when the ground is wet and soft, the ditching spade may be used to good advantage for removing the earth almost to the grade line, and the bottoming scoop may be used to secure

a smooth, even bottom. But as soon as the ground becomes too firm for spading, either operations must be stopped or some method of loosening the earth employed. "Experienced ditchers" usually choose the former, so that for a large part of the year they busy themselves with other work, for if they have to use the pick they "cannot make wages" in the hard ground. With a team of horses and a plough at one's disposal, however, ditches can be dug as cheaply in the summer and fall as they can with the spade and scoop in the spring.

Perhaps the most effective way of using the plough is somewhat as follows:

(1) Using an ordinary plough, the drain is opened up as wide as possible, one furrow being thrown each way. In stubble, fallow or

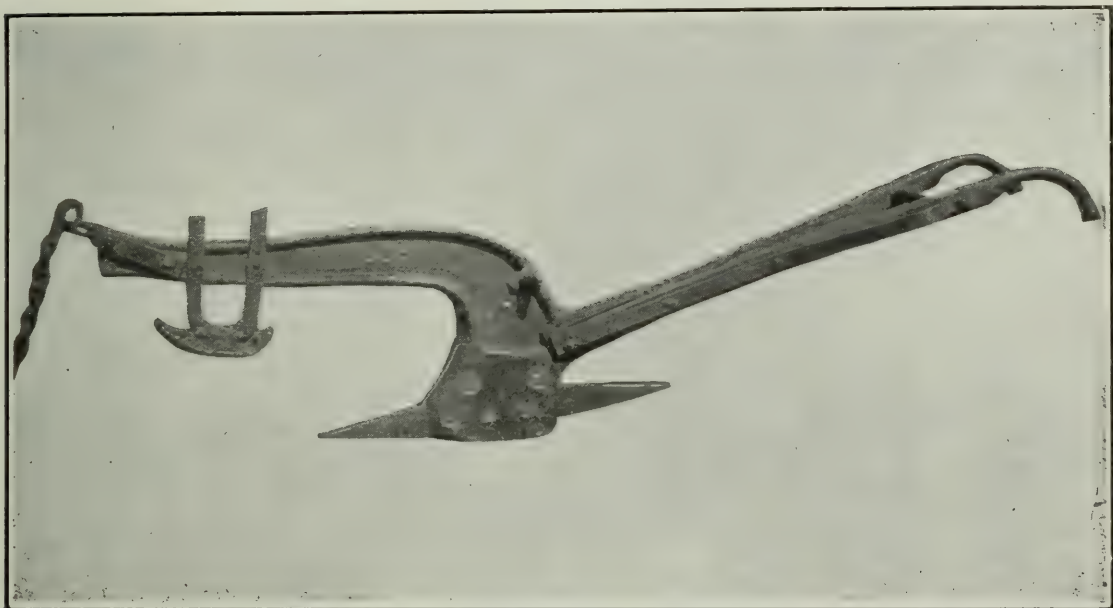


Fig. 16. The pick plough.

ploughed ground these furrows will not need shovelling, as they will be thrown well out; in sod they may need rolling farther back.

(2) Using an ordinary plough, two more furrows are turned, one each way, in the bottom of the ditch already formed, each furrow being thrown toward the centre of the ditch. The second will turn the first back partly, but this serves only to loosen the soil more thoroughly. The sides of the ditch, which were very sloping after the first ploughing, have been trimmed off perpendicular and straight by the land-slide in the second ploughing, which is now ready to shovel out; and it will be found in prime condition.

The ditch at the present stage should be about 18 inches wide. It may be objected that this causes needless shovelling, to which the answer is that the plough is to be used till the ditch is $2\frac{1}{2}$ to 3 feet deep,

and it is necessary to have the top wide enough to accommodate the handles. The bottom will not be as wide.

This operation should be repeated till the ditch is about 15 or 18 inches deep. In order that the horses may walk comfortably, one on each side of the ditch, the lines are opened up as wide as possible and a long doubletree used. To permit the plough to go deep enough in the ground, a chain about six or eight feet long is put in between the beam and the doubletree. This plough will not be found satisfactory after a depth of 15 or 18 inches is reached, as the drain gradually becomes narrower.

(3) Now using a *drainage plough* of some sort, a furrow is ploughed right down the centre of the drain and another in the same groove coming back. This forms a narrow ditch in the bottom, both sides of which are trimmed straight and perpendicular. With a narrow shovel this furrow may now be removed. This operation is repeated again and again until the drain is almost as deep as required.

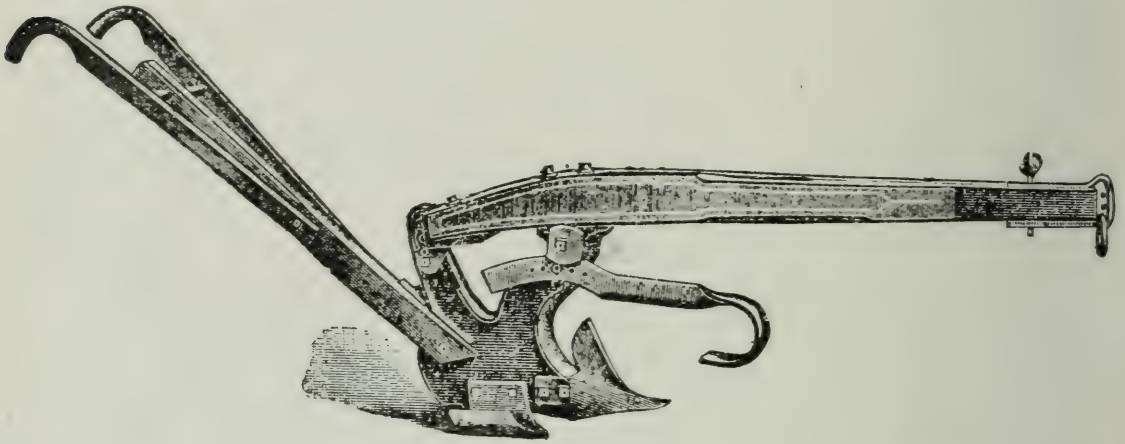


Fig. 17. Ditching plough.

For this third operation a special plough is necessary—we want something to dig a narrower trench than heretofore. A home-made ditching plough may be made as follows: Take an ordinary plough and remove the mould-board. This of course removes the attachment for the lower end of the right handle, but bolt a narrow block between the handles and run a brace from it to the back bolt in the beam, and the handle is as steady and as firm as ever. Put on a new narrow point. If one has much draining to do, it is advised to make further and permanent alterations. The rod between the handles should be taken out, shortened, and replaced, thus bringing the handles closer together. The top section of the ditch need not now be so wide as before. It is also wise to shorten somewhat the braces that run from the head to the handles, thus raising the latter; the wide section of the ditch need not be so deep as before. An ordinary subsoil plough serves very nicely where the ground is not too hard. The “pick plough” manufactured by various plough companies

is far better. (Fig. 16.) So also is the special ditching plough manufactured by one of our Ontario firms. (Fig. 17.)

In hard ground the home-made drainage plough is very difficult to control when the ditch becomes deep—sometimes it goes too deep, at other times, because of its lightness, it skims along the surface, doing no good. The subsoil plough, too, has these defects, and besides it is not strong enough in very heavy soil. I have seen a subsoil plough twisted so out of shape as to be useless for any purpose, and that simply because of the stiffness of the soil and uncontrollability of the plough. The pick plough and the ditching plough have none of these defects—they are heavy and therefore strong enough for all purposes, ride steadily at a uniform depth and are easily held. Because of their weight they are somewhat cumbersome in turning at the end, but they perform their work so effectively that this slight drawback may be overlooked. The pick plough is not made primarily for drainage work, but for tearing up pavement, old roads, etc., hence the handles, as in an ordinary plough, are too low and too wide. But they can be raised and narrowed as described above—which was actually done on some of them which I have seen used for drainage purposes.

Actual test has shown that the “pick plough” reduces the cost of digging by 42 per cent. compared with pick and shovel. The “ditching plough” probably does about the same. It is found that they can be used to depths of four feet or over, and some who have followed this method claim that even if the ground can be spaded it is cheaper to use the plough and shovel method.

GRADING THE DITCH.

Having dug the ditch within a few inches of its final depth, the next operation is to remove the remaining earth, leaving the ditch bottom with an even fall throughout. The accompanying drawing (Fig. 18) will aid in understanding the method to be described:

Two cross-heads are set up 100 feet apart, one at stake 0 and the other at stake 100, as shown in Fig. 18. Both are put 6 feet 6 inches above the ditch bottom, the one at stake 100 thus being higher than that at stake 0 by the amount of fall in 100 feet, *e.g.*, if the fall is 14 inches in 100 feet, then cross-head 100 is set just 14 inches higher than cross-head 0. The stakes must be stout and driven firm in the ground. A light cord—binder twine does very well—is then stretched *tight* and tied over the cross-pieces, so that the sag is negligible. Since one end is 14 inches higher than the other, this cord has the same fall as the ditch bottom is to have, and hence if the latter is made parallel to the cord it will have the required fall. It is necessary to provide a light testing or “travelling” stick 6 feet 6 inches long, since the cord is that height above the ditch bottom. With a narrow shovel the earth is gradually removed until the stick standing on the ditch bottom just passes under the line, as shown in the drawing. When such is the case the ditch is deep

enough at that point. When every point between stakes 0 and 100 just test 6 feet 6 inches from the overhead line, the grade of this section is uniformly 14 inches in 100 feet. Any other grade is arrived at in a similar way.

But how shall we place the cross-heads 6 feet 6 inches above the ditch bottom?

First.—If not already known, we must determine the depth of the ditch at the outlet. A drain usually empties into another tile drain or into an open ditch, the depth of either of which may be determined by using the drainage level and the measuring staff as follows: Set up the

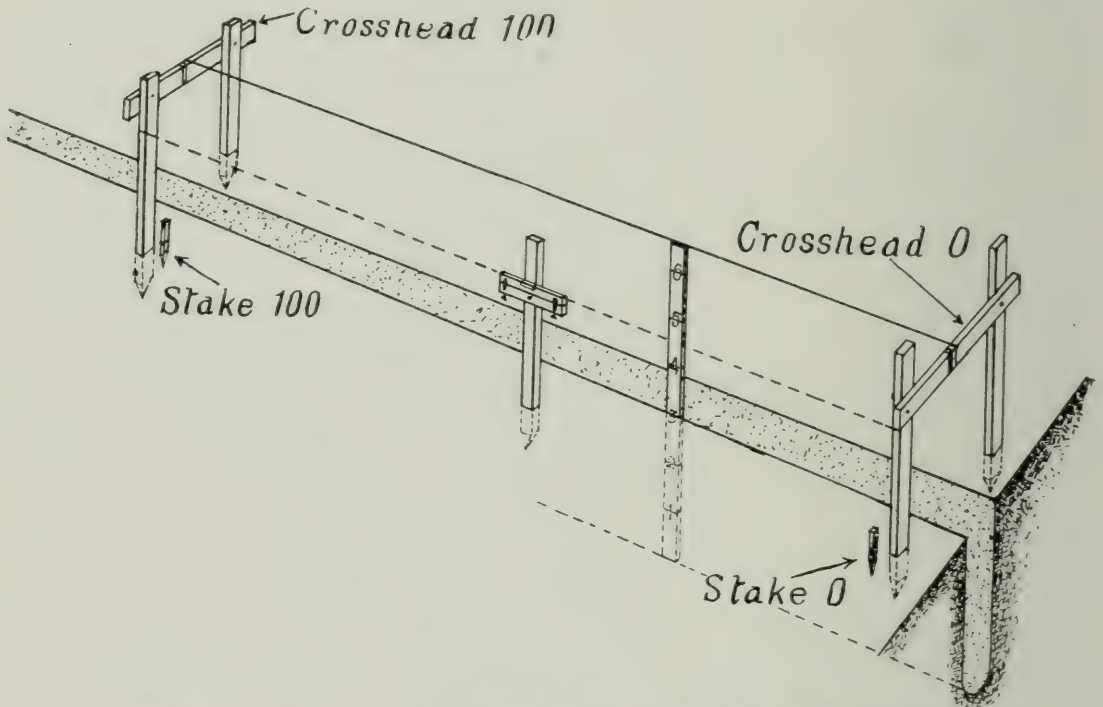


Fig. 18. Overhead line method of grading a ditch bottom.

level as previously directed and sight over it at the staff, which is placed first on the surface of the ground, and second on the bottom of the main drain or of the open ditch, taking readings in both cases. Subtracting the readings, we have the depth of the ditch at the outlet. Suppose for illustration that it is 3 feet 5 inches.

Second.—We must determine the height the cross-piece at stake 0 is to be placed above the ground. This is done by *subtracting the depth of the ditch from the length of the testing stick*, i.e., if the ditch is 3 feet 5 inches deep, as supposed above, then cross-head 0 would be 6 feet 6 inches minus 3 feet 5 inches = 3 feet 1 inch above ground. One end of the cross-piece is clamped or nailed to one of the stout stakes at this height (3 feet 1 inch), the cross-piece is then levelled by means of the spirit level, and the other end fastened to the other stake.

Third.—We must find a point on stake 100 that is higher than cross-

piece 0 by the amount of fall in 100 feet, and fasten the cross-piece at that point. For instance, if the fall is 14 inches in 100 feet cross-piece 100 must be nailed 14 inches higher up than cross-piece 0.

To do this we set up the home-made drainage level about half way between stakes 0 and 100, sight to both stakes, as shown by the dotted line in Fig. 18, and put marks on the two stakes. *These marks are level with each other.* We now measure the distance between cross-piece 0 and the mark. Let us suppose cross-piece 0 is 6 inches above the mark. Then cross-piece 100, to be 14 inches higher, must be 6 plus 14, or 20 inches, above the mark on it. If cross-piece 0 is below the mark, we subtract the distance from the grade or the grade from the distance to find how far cross-piece 100 must be above or below the mark, e.g., if the grade is 14 inches in 100 feet and cross-piece 0 is 6 inches *below* the mark then cross-piece 100 must be 14 inches minus 6=8 inches *above* the mark, but if cross-piece 0 is 18 inches below the mark then cross-piece 100 must be 18 minus 14=4 inches *below* the mark. For any other grade the cross-pieces are set in a similar manner. When they are thus placed, the cord which is tied stretched over them is 6 feet 6 inches above the ditch bottom and parallel to it.

But why have the overhead line 6 feet 6 inches above the bottom? Usually 6 feet is not enough to clear the man and his shovel; 7 feet would be more than is necessary, unless it is a very deep ditch.

To grade the second section of the ditch a cross-head must be set at stake 200. This may be roughly done by sighting it in line with cross-heads 0 and 100, but it is always wise to set up the level and by means of it get cross-head 200 placed exactly the right amount above cross-head 100. The same applies to subsequent sections.

In practice it is found convenient not to tie the line to the cross-pieces, but to simply pass it over them and tie a fairly heavy stone to it. This keeps it always at the same tension and takes up any stretch that may occur. As a heavy line sags some on a 100 feet section, it is usually found best to interpose one or two light cross-heads between the end ones, by which they can be sighted in position. Instead of intermediate crossheads some use two light sticks, bolted together at the top like the letter A, with notches in one of them for the line, which may be raised or lowered either by the use of the notches or by closing or spreading the bottom of the sticks.

There are numerous devices for aiding in digging a ditch to the required grade, but the overhead line here described is, in our judgment, the best we have seen. We know men who have abandoned others in its favour, but none who have abandoned it for others.

LAYING THE TILE.

When the first section has been graded, and while the line is still strung, it is wise to lay the tile, so that they may be tested to grade by the same line, a notch being cut in the testing stick at a distance from

the end equal to the outside diameter of the tile. This gives the best alignment of the tile, and the fewer irregularities there are the less the danger of partly or wholly blocking with sediment. Another reason for not allowing the digging to get too far ahead of the laying is that rain is liable to occur at any time, causing the sides to cave in and otherwise interfering with the finished bottom.

Good joints need no protection against sediment, except in quicksand, but joints that are at all open should be covered to prevent sediment entering the tile while the earth is becoming set. Sods placed with the grass next the tile are excellent for this purpose. Tar paper also is good, but it should not go all round the tile, it should lack two inches or so of meeting on the under side. This precaution allows the water to enter the joint from below. There is practically no water enters through the pores of the tile. Some years ago I sealed one end of a 3-inch, a 4-inch, a 5-inch and a 6-inch tile and set them in water one foot deep sealed end downward, putting weights on them to hold them down. They were left in that position for 44 hours. At the end of that time the amount of water in them varied from $\frac{1}{4}$ to $\frac{3}{4}$ of a tumblerful, showing that water passes very slowly through the pores. Then it must enter through the joints, hence the precaution of putting the tar paper over the top and sides only. When quicksand is encountered, the tile may be laid on strips of board about six inches wide. In case tile have to be laid near water-loving trees, such as elms, willows or soft maples, they are almost certain to be blocked with roots in a year or two. The safest plan is to sacrifice the trees. If this is not done, sewer tile should be laid in that section of the ditch and the joints cemented, but tile so laid do not drain the land through which they pass. The roots of fruit trees sometimes block tile when laid too shallow and too near the trees, hence tile in orchards should be laid rather deep and midway between rows of trees where possible.

None but sound tile should be laid. This point cannot be too strongly emphasized. Early last spring I chanced to call at a farm which I had surveyed some years previously, and which had been drained in the meantime. "There's no use putting in tile on that piece yonder," said the owner, pointing as he spoke to one of the finest parts of his farm.

"Why?" "Because the soil is so fine it washes right into the tile," was his answer. "That man working there is digging up a drain now where there was a wash in."

I remembered the soil, and believed it should drain all right. We went over and examined the spot, and I was convinced the fault was not in the soil, and said, "There is a flaw in your tile."

"Well, the digger hasn't found any; here they lie, all perfect."

"Then there was a flaw in the laying."

The point was soon decided, however, for the next tile taken up was imperfect. About half way round one end there was a half-inch piece broken out.

"Well, now, I told those fellows not to put in any broken tile" was his response. "They hadn't any experience in tile-laying, but I thought they could do this little piece all right, seeing it has such good fall."

Sound tile, and reliable, experienced men to put them in, is a good motto.

Sometimes two lines of tile are laid in the same trench. This practice is not to be commended, as the water flowing in the triangular space between them is liable to wash away the soil in soft spots, causing the tile to side roll and partially or wholly block the drain.

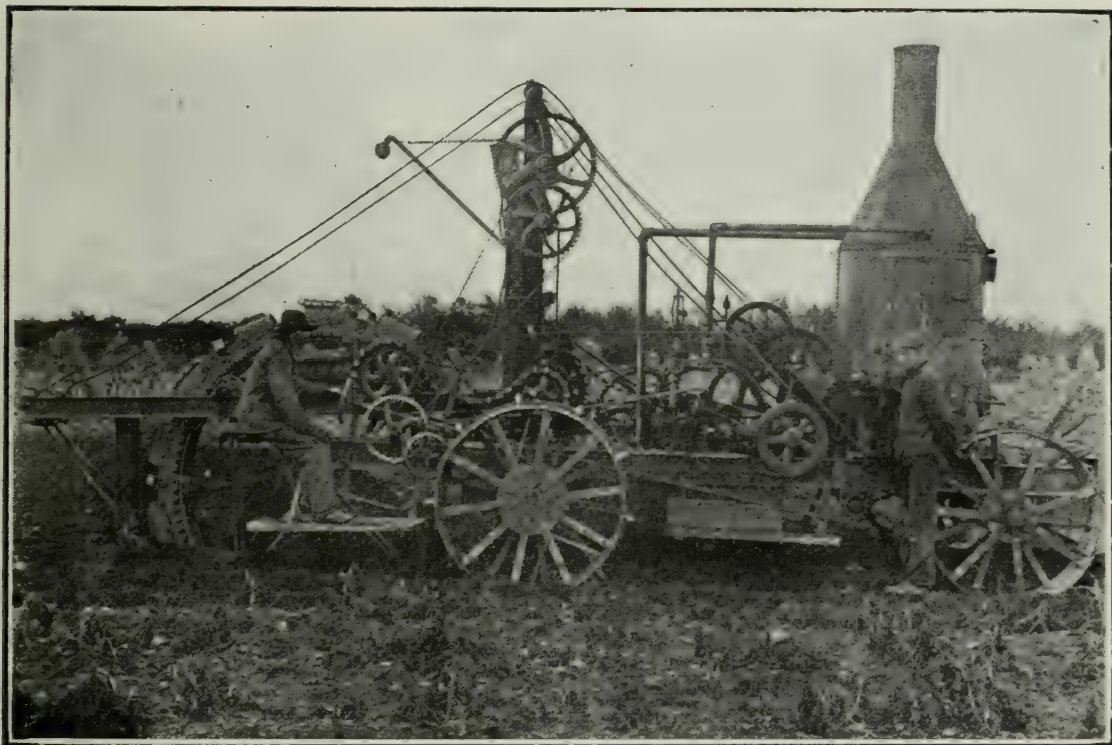


Fig. 19. The steam ditcher, working on the farm of J. A. Lind, Beamsville, Ont.

THE STEAM DITCHER.

The discussion of methods of construction would not be complete without some reference to the traction ditching machine, which is now being introduced into Ontario. It digs the ditch full depth, true to grade, and leaves the bottom ready for the tile in passing once over the ground. They are manufactured by the Buckeye Traction Ditcher Co., Findlay, Ohio. Fig. 19 shows one of these machines in operation on the the farm of Mr. J. A. Lind, Beamsville, Lincoln County. It is owned by Mr. Walter Day, the writer's brother. The machine began operations in May, and what the people think of the style of ditch it digs may be judged from the fact that it has not once been short of work in the meantime, and that it has more jobs ahead of it now than when it began

in the spring. In clean land it easily averages from 90 to 100 rods of 3-foot ditch per day, including stops, sometimes digging 130 to 140 rods a day. In very stony land it has dropped as low as 50 rods average on one job, while on others, with less stone, it has averaged 75 rods. From my intimate knowledge of the performance of this machine during the past five months, I say without reserve that the steam ditcher has come to stay. It will revolutionize ditching operations in Ontario in a few years—indeed, it will solve the “labour problem” so far as ditching is concerned.

FILLING THE TRENCH.

The filling of the trench needs little comment. A small amount of earth should be shovelled in, just enough to protect the tile, and then

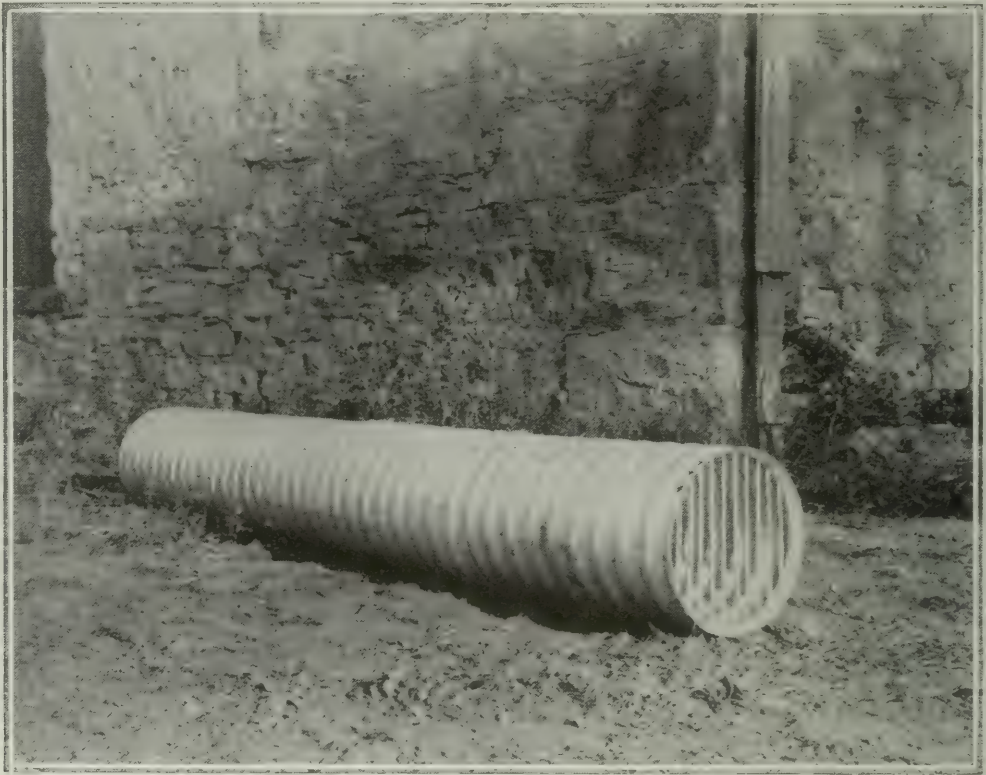


Fig. 20. Side view of corrugated metal outlet.

the plough may be used to good advantage. A few rounds will fill the trench completely, and a good crown should be formed to protect the drain from large quantities of water washing into it through the porous soil at the first rain. The crown sheds the run-off water into the furrows at the side. Some use the road grader for filling, others the “road planer,” something similar to the grader, but with a smaller mould board, not reversible, mounted on three small wheels. Others use the ordinary drag scraper, and even the split-log drag does fairly well. Perhaps for the majority of people the plough is the most convenient.

PROTECTING THE OUTLET.

The outlet is often a source of trouble. Clay tile, if exposed to repeated freezing and thawing, as they are at the outlet of a drain, will chip and crumble, allowing the earth to drop down and obstruct the flow of water, and often the stock tramp on and break them. Sometimes the water undermines them and they side roll. To overcome these difficulties wooden boxes, from 6 to 12 feet long, are frequently used. Sometimes the last two or three feet of the ditch is built up with concrete surrounding the tile. Sewer crock are frequently used for the last four or six feet. All of these devices are good, and are preferable to leaving the end tile



Fig. 21. End view of corrugated metal outlet.

exposed, but the wood soon decays at the end, the cement may be broken in time if undermined, and the sewer crocks are subject to displacement by undermining. Since corrugated metal culverts have been coming into use, it has occurred to me that a six or eight-foot length of corrugated galvanized iron pipe would make an ideal outlet for tile drains; and, besides, if one end was fitted with cross-rods, as it might easily be, it would give a sure protection against muskrats, which sometimes infest and block the drains. During the summer of 1909 a gentleman living near Beamsville, Lincoln County, put in a system of drains. After the first heavy rain in the autumn he went down to the outlet to see if they

were working. He was just in time to see a muskrat nest float out of the main drain. If, as often happens, it had been too securely lodged to be driven out by the water, the whole system would have been partially or wholly blocked. I have discussed the point with some of the metal culvert people, and, as a result, am able to present herewith side and end views of such an outlet. (Figs. 20 and 21.) A six or eight inch tile of this kind can be had for about 35 cents a foot, with 50 cents extra for the cross-rods. The ten and twelve inch sizes would be worth 40 cents a foot, with the rods extra. The rods, as well as the pipe, would be galvanized. I see no reason why this should not be superior to either lumber, cement, or sewer crock for outlet protection.

The outlet should be protected in still another way—the open ditch or creek below the tile should be kept well cleaned out. If it is allowed to fill up and interfere with the free escape of the water from the tile the efficiency of the drain is impaired in a like degree. Perhaps there is no more fruitful source of trouble with drains than the failure to keep the outlets free. Once each year they should be inspected and put in proper condition.

SAND TRAPS.

Sometimes it is impossible to get steep enough grade in drains to insure a velocity of water sufficient to flush all sand from the tile. This condition may be aggravated by turns in the drain, the entrance of laterals, or a change from a steep to a slow grade, all of which check the velocity of the water. In such cases sand traps should be used at the troublesome points. These consist of boxes of wood, brick or concrete, from eighteen inches to four feet square, depending on requirements, and about two feet deeper than the drain. Fig 22 shows a section of one of them. The water flows much more slowly in the box than in the tile, consequently the sand settles, leaving the water clear as it emerges. This object is better attained by having the outlet and inlet tiles diagonally across rather than directly opposite each other. If they are opposite, the water tends to flow straight through, with only a slight check in speed, and little chance for the sand to settle; but if diagonally across, it has to make two turns, and its velocity must be greatly reduced. It is also well to have the inlet at least half the diameter of the tile higher than the outlet, as this gives the former better clearance when nearly empty. These traps should be examined from time to time, and cleared of sediment as occasion demands.

The first drainage survey the writer made was one demanding a sand trap. Mr. Noah Bechtel, who lives a few miles out of Berlin, had three troublesome springy spots on a side hill. The soil was a sandy loam. The three drains from the springs had to be united in the flat, where the velocity of the water would be much slower than coming down the steeper grades. A sand trap twenty inches square was placed

where the three met, and a main led from it. The next summer, when in Guelph one day, Mr. Bechtel took the trouble to come out to the College to report. He said the cement for the box cost him 50 cents, and he and the boys built it in about a quarter of a day. In the one spring it had filled with sand almost up to the tile, but in half an hour they had cleaned it out,

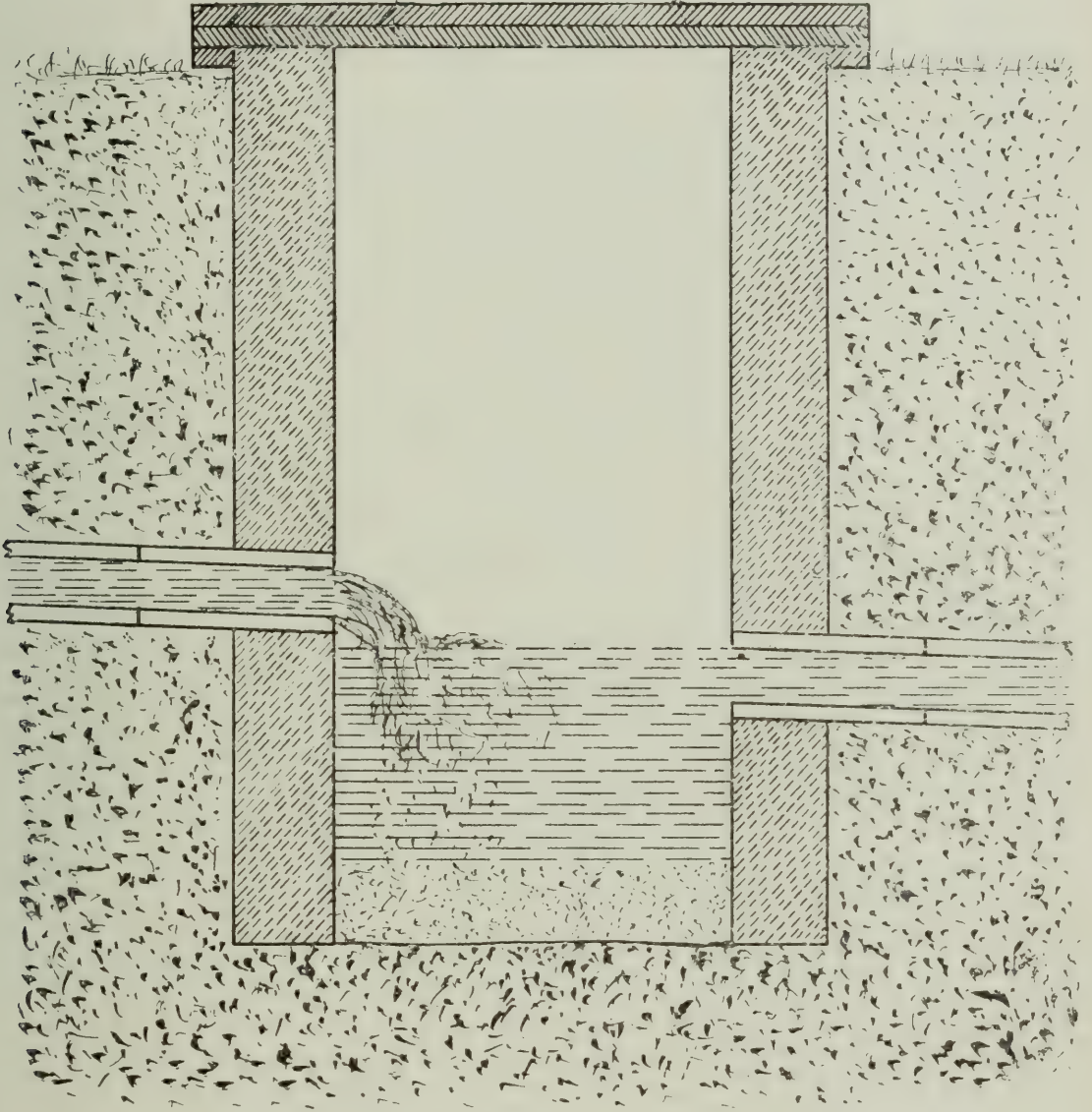


Fig. 22. Sand trap.

and it was then ready for the next spring. Indeed, it has been found necessary to clean it once each year.

Where the grade is so slow that sand is likely to bother, the traps should be placed at turns and junctions, also where the slow grade begins, and at intervals of 400 to 600 feet in long stretches not affected by turns, junctions, or changes in grade.

There is another use for these traps that is worthy of mention. In some cases it is found wise to lead an open drain into a tile. A sand trap with a screened side toward the open ditch is the best form of junction. The screen keeps out practically everything but sand, and the trap catches that. The tile will not carry all the water that comes down the open ditch at times of freshet, so it is wise to leave over the tile a depression with very flaring banks for the surplus. As soon as the freshet is over, the tile takes the remaining water. The depression is no obstruction to tillage, and will grow crops as well as the rest of the land.

Many sand traps have been observed in various districts, and often they are large, unsightly things that obstruct farming operations considerably. It seems to me that all that stands above ground is waste material. Less expense would build a strong cover just level with the ground, and then these traps would be neither eye-sores nor serious obstructions.

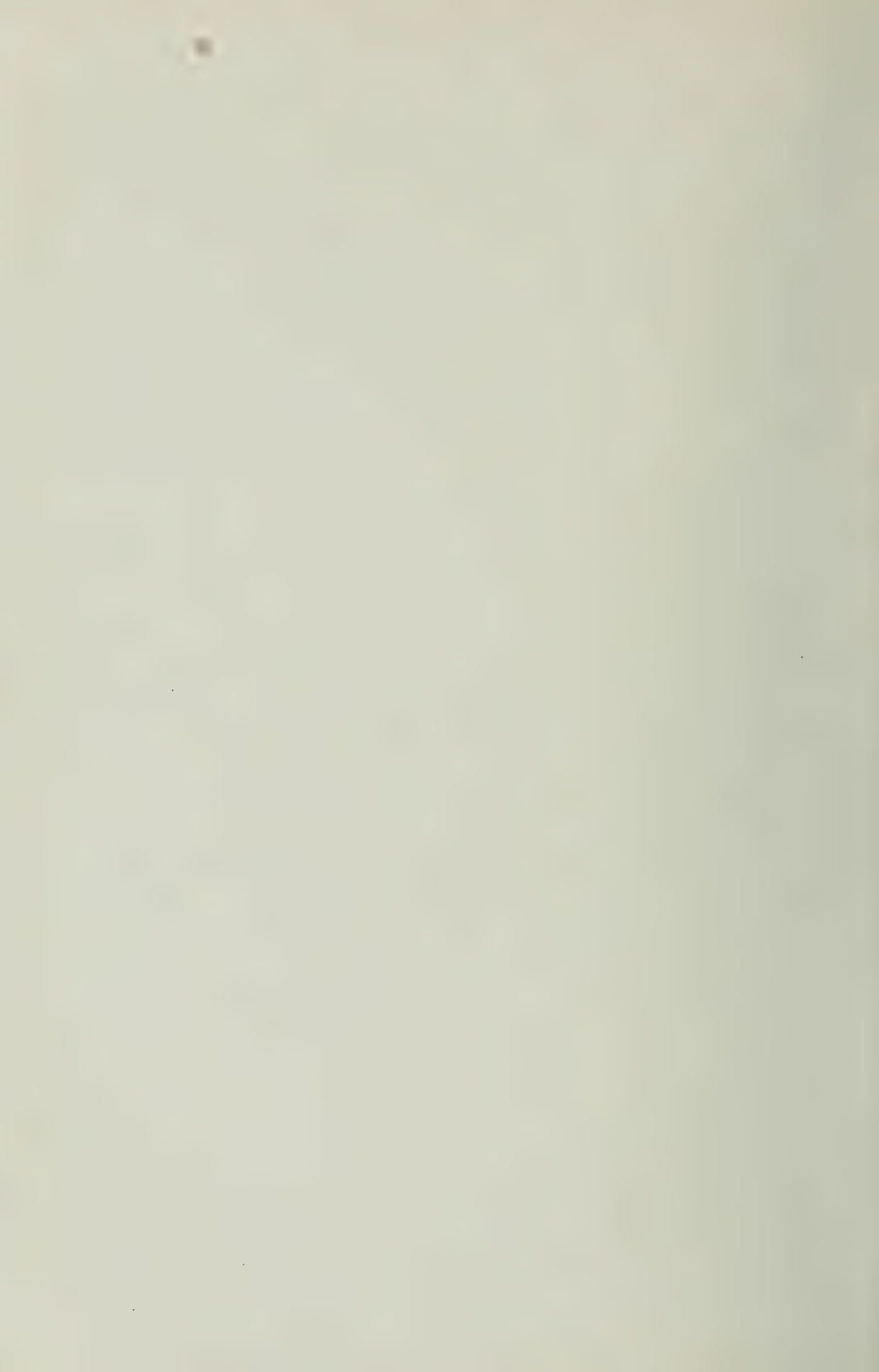
CONDITIONS ON WHICH SURVEYS ARE MADE.

It may not be out of place to state, in conclusion, the conditions on which drainage surveys are made. There is no charge for the services of our drainage advisors, their salary being paid from a special drainage appropriation, but their travelling expenses, consisting of railway fare at a cent a mile each way for this work, meals on the way, if any, and cartage of instruments, if any, must be paid by the parties for whom surveys are made. They must be met at the station and returned to it, accommodated while on the job, and furnished with the necessary assistance for the work. As several surveys are usually made on one trip, the actual cash outlay for any one farmer is not likely to exceed \$2. It may be even less; or, in exceptional cases, where farmers live in remote sections, it might amount to \$5.

Those wishing to make application for surveys should address the department of Physics, O. A. C., Guelph, whereupon regular application forms will be sent.

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" TWIG BLIGHT " ON APPLE.
(Blossom inoculation. Disease passing down twig.)

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

BACTERIAL BLIGHT

Of Apple, Pear and Quince Trees.

By D. H. JONES.

INTRODUCTION.

Owing to numerous and repeated inquiries from fruit growers in various parts of the Province of Ontario regarding the cause of and remedy for the blighting of their apple and pear trees, it was decided in the spring of this year that the writer should devote as much time as possible to investigation in connection with the disease.

In accordance with this decision, the Ontario Agricultural College orchard has been under constant surveillance during the season; orchards in the Niagara, Grimsby, St. Catharines and Winona districts have been visited three times, orchards in the neighbourhood of Belleville and Pickering visited once, and numerous experiments in the College orchard and in the laboratory have been carried on.

Conditions throughout the season have proved very favourable for the investigation; the disease has been plentiful in all its stages in the various districts of the Province visited, and in the College orchard, which, at our request, was not treated for blight throughout the season, material for study has been abundant.

HISTORY OF THE DISEASE.

The disease which is known under the various names of Fire Blight, Twig Blight, Blight Canker, Pear Blight, and possibly others of local application, is of long standing on the North American continent. It has wholly destroyed many pear orchards, and has been very destructive to the apple and quince crops in nearly all parts of Canada and the United States where these fruits are cultivated.

In the volume, "Cultivation of Fruit Trees," published in 1817, which is said to be the oldest American book on fruit culture, William Coxe writes of the "fire blight which frequently destroys trees in the fullest apparent vigour and health, turning the leaves suddenly brown as

if they had passed through a hot flame and causing a morbid matter to exude from the pores of the bark."

From 1817 until 1878-80, when Burrill discovered the specific cause of the disease, many and varied were the theories advanced as to the cause. Among these may be mentioned, 1, electricity or atmospheric influence; 2, stroke of the sun; 3, old age or a long duration of varieties; 4, sudden freezing of the bark; 5, freezing of the roots whereby absorption is prevented, supply of moisture cut off and the evaporation of moisture from the branches, so causing the blight; 6, too high culture; 7, absence of certain mineral matters from the soil; 8, insects; 9, fungi; and 10, epidemic transmitted from place to place by air. Some of these theories still have their champions among fruit growers.

Harrison, in Bulletin 136, O. A. C., quoting other authorities, says:

"In the early days of fruit growing in the Niagara district we had no pear tree blight nor apple tree blight. With the advent of what people

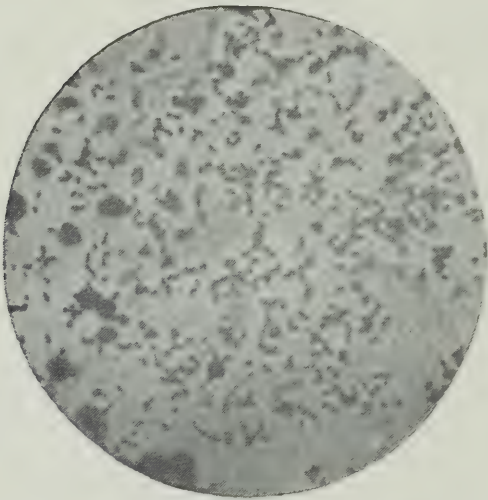


Fig. 1. *B. amylovorus*, a smear preparation made by macerating a little of the inner bark of a diseased apple twig from which the viscid liquid was oozing.

Stained carbol fuchsin X 1000.

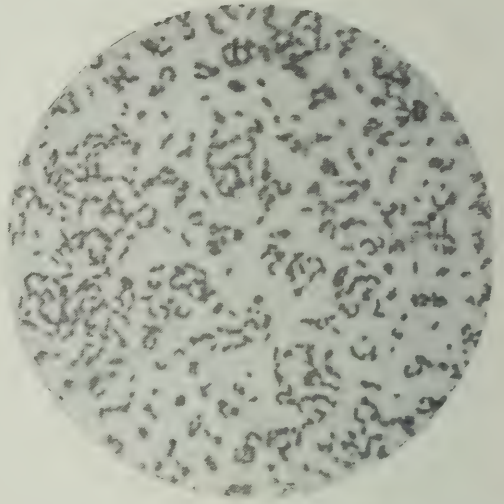


Fig. 2. *B. amylovorus*, smear stain from colony on agar four days old. Stained carbol fuchsin. X 1000

termed grafted fruit, there came, after a few years, 'blight' on the pear tree. By the year 1840 it had spread considerably. N. J. Clinton, of Essex County; S. Hunter, of Oxford; E. D. Smith, of Wentworth; Stone and Wellington, of Welland, and R. Hamilton, of Argenteuil, reported its presence in their respective counties about thirty-five years ago. The colder parts of the province have suffered from the disease as well as the more favoured districts. The orchard of the Dominion Experimental Farm, at Ottawa, has been attacked, and the 140 Russian variety of apples cultivated there have suffered severely. In warmer districts, however, the disease has been more severe. Whole orchards have been completely destroyed in the State of Texas, and certain pear growing districts in that State have been practically ruined by this parasite.

"LOSSES. No statistics are available to give us an idea as to the amount of loss to fruit growers from pear blight, but a few references to losses by this destructive disease will help to give us an appreciation of the subject. Coxe, in 1817, reported that he had lost upwards of fifty trees in twenty years. In the years 1826, 1832 and 1844 there was an increased prevalence of the disease, and few pear orchards escaped without partial or total loss of many trees, and some orchards were quite destroyed. Downing called it the 'monstrous malady of the pear.' Lyons stated, as the opinion of many cultivators in the State of Michigan, that, 'The pear cannot be grown with financial success on account of the blight.' Hallam, in 1882, reported that 'In Southern Illinois, pears have failed—utterly failed—so that none are now cultivated for market. The blight has destroyed the trees, branch and root;' while A. Noice, of the same State, doubted 'if one-tenth of the pear trees that are planted lived ten years on account of this destructive agent.' E. H. S. Dart stated that the severities of winter were not so much to be dreaded as the ravages of blight. He had in 1874, one to two thousand trees affected. Dr. P. A. Jewell, in 1876, lost 10,000 Tetofsky apple trees by it. Bailey, of Cornell, declared that fire blight was undoubtedly the most serious disease with which the quince grower had to contend. It is the same disease which is so

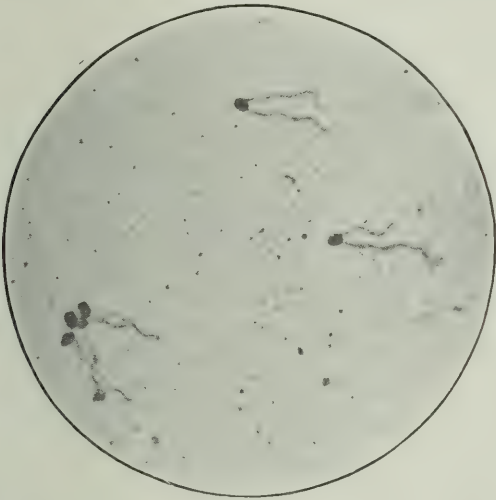


Fig. 3. *B. amylovorus* stained to show flagella; made from an agar culture seven days old.

Moore's modification of Loeffler's flagella stain. X 1000.

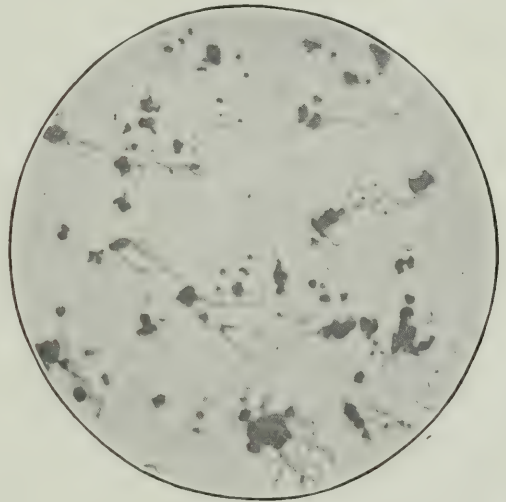


Fig. 4. *B. amylovorus* showing flagella; cells massed together in clumps.

Moore's modification of Loeffler's flagella stain. X 1000.

destructive to pear orchards in certain years and to certain varieties of apples, particularly the crabs. Selby, of Ohio, reported that the disease ranks among the most destructive known to the orchardist in his State. Chester, of Delaware, announced that pear blight was of unusual severity during the season of 1901, and caused much alarm because of its rapid spread through the orchards of the State. In 1895 its ravages in Ontario were most severe on apple trees in the vicinity of Hamilton and Burlington Bay."

Our observations this year have shown that the disease is wider spread than ever before, is continually spreading into new territory, and is causing heavier losses than formerly to the fruit growers.

From these statements it will be perceived that the blight of apple, pear and quince trees is widespread on the North American continent, and

is of long standing. If anything effective is to be accomplished in its control, extensive and radical measures must be adopted, not only by those directly interested in the production of fruits subject to its attack, but also by those authorities who have under their control the roadsides and waste places where trees subject to its attack harbour the disease. Other trees besides the apple, pear and quince, both cultivated and wild varieties, subject to the disease, are the hawthorn (*Crataegus*), June berry (*Amelanchier*), and the mountain ash (*Pyrus*).

THE DISEASE, ITS CAUSE AND APPEARANCE.

CAUSE.—*Bacillus amylovorus* (Burrill).

B. amylovorus is an organism averaging about 1.5 microns long and .6 microns broad. A micron is 1-25000 of an inch, therefore it would take over sixteen thousand placed end to end, or over forty-one thousand placed side by side to extend one inch. As seen through the microscope, 1-12 oil immersion lens, it appears sometimes oval in shape, sometimes almost spherical, but more often cylindrical with rounded ends. (Figs. 1 and 2.) The cells are usually single, though often in twos, seldom in threes or chains. Often, however, they are found in small clumps, the organisms evidently being matted together by the interlacing of their flagella.

They have from one to four flagella, usually only two, which are from 6 to 12 microns long and usually situated at or near the poles. (Figs. 3 and 4.) They are usually actively motile.

GENERAL APPEARANCE OF THE DISEASE IN THE TREE.

The disease may occur in the bark of the twig, the branch, or the trunk of a tree and also in the fruit, more especially in immature fruit. Any one or all of these parts in the same tree may be affected, and the disease may spread from one part to another.

The disease is found on the apple tree more often in the form of twig blight, and on the pear tree in the form of body blight. Cases of body blight, however, occur in apple trees and cases of twig blight occur in pear trees. The reason that body blight is more common in pear trees appears to be because the bark of the pear tree is more spongy, thicker, and more juicy than is the bark of the apple tree; and these conditions are most favourable for the rapid and continuous development of the organism. These conditions exist in the young growth, *i.e.*, the twigs, water-sprouts, and suckers of the apple tree; and hence when the organism finds entrance to these parts the disease develops there and progresses down the affected part until it meets with adverse conditions, which it usually finds in the bark of the large branches or the trunk of the tree. And so, as a rule, it is only the young growth of the apple tree

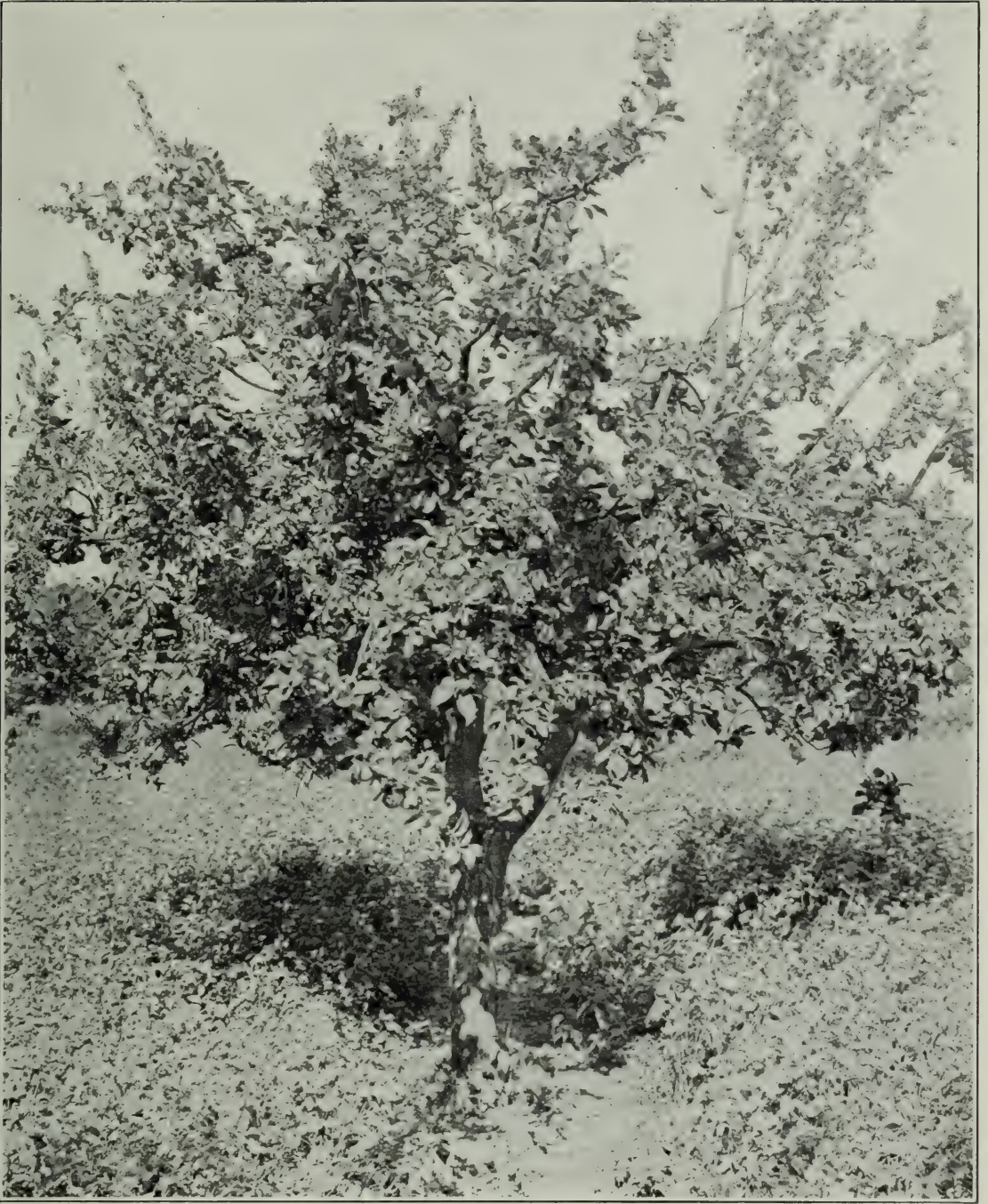


Fig. 5. Mature apple tree (Romenskø) badly affected with twig blight.

that is destroyed by the disease, and the tree affected survives the repeated attacks from year to year, until eventually it may become so impoverished from having its young growth annually killed that it will cease to be profitable and so call for removal. The disease, too, may find suitable conditions in the apple tree for its continued development, and in such cases we get its gradual spread in the limbs and trunk in canker form, until eventually the tree succumbs. (Fig. 36.) With the pear, on the other hand, as already stated, the disease when once it gains entrance spreads rapidly; it may destroy a tree in one season, and usually three years is the limit of life of a tree after it has once contracted the disease. (Figs. 7, 25, 26, 27.)

I.—THE DISEASE IN THE TWIG.

This phase of the disease is known as twig blight, or fire blight; the latter because a tree so affected looks as if it had been scorched by fire.



Fig. 6. Detail from tree shown in Fig. 5. (Note the dead, shrivelled leaves.)

It may occur in blossom twigs, foliage twigs, water-sprouts and suckers. The blossoms and leaves of affected twigs become discoloured, turning light or dark brown, sometimes red, shrivel up and die, and remain attached to the twig sometimes throughout the winter. (Figs. 5, 6, 8, 9.)

This discolouration and death of the leaves and blossoms occurs comparatively suddenly, and may occur at any time from May to September. The suddenness of its appearance is somewhat disconcerting to the fruit grower who may walk through his orchard one day and find his trees looking apparently all right, but in visiting them again a few days later he finds many blossoms and leaves dry, brown and shrivelled. This

discolouration and death of the leaves and blossoms does not mark the beginning of the disease, but rather its last stages in those parts so affected, and the disease will have been present in such twigs several



Fig. 7. Diseased Bartlett pear tree. Disease active in this tree four years; dead limbs cut away from time to time. Limb to the left died this season; limb to the right badly diseased.

days, often a week or more, before it is noticed by the casual observer. Hence, the disease is not so sudden in its onslaught as is popularly supposed.



Fig 8. Blighted apple twig; inoculation through blossoms on the two end spurs, presumably by bees. Disease passed down pedicels to spur, then to twig, killing the end of the twig. Apples developed below the diseased area, but the disease later passing further down the twig would prevent their maturing.



Fig. 9. Apple twig with two blighted spurs. These inoculated through the blossom. The disease had passed from the spurs to the twig, and when photographed the twig was girdled by the disease near the spurs and the apples and leaves at the tip had ceased developing and would soon wither.

If the bark of twigs that bear the discoloured leaves and blossoms be cut and examined, the affected area will be found to be shrunk and discoloured a dark reddish brown, or purplish. Sometimes the bark will be blistered and often on such blistered areas there will be present the somewhat dried remains of a gummy exudate. This gummy exudate bursts through the blistering areas or oozes through the pores of the bark when the disease is actively progressing in an area that is well charged with sap. On first appearing, the exudate is transparent and almost colourless, but as the moisture evaporates from it, it becomes first amber colour, then brown, and finally a dark reddish brown when dry.



Fig. 10. Recently blighted pear twig. Disease very active; exudate on surface of bark. Note the small exudate globules scattered all along the stem.

(Fig. 25.) *This exudate is literally crowded with the germs of the disease*, and if by any means, either by insect, workman's tool, or careless handling of diseased parts of trees, it finds entrance to the bark of a healthy tree, there the disease will develop.

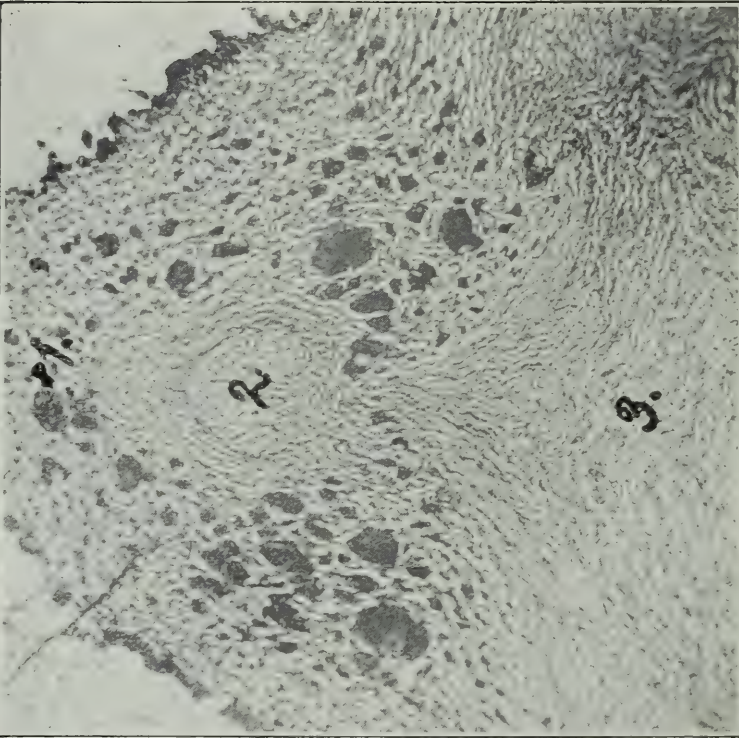


Fig. 11. Cross section of diseased pedicel of young apple. 1, bark; 2, vascular bundle; 3, wood. The darkened areas in the bark are cells surcharged with *B. amylovorus*. Section 4 microns thick, stained carbol fuchsin. X about 50.

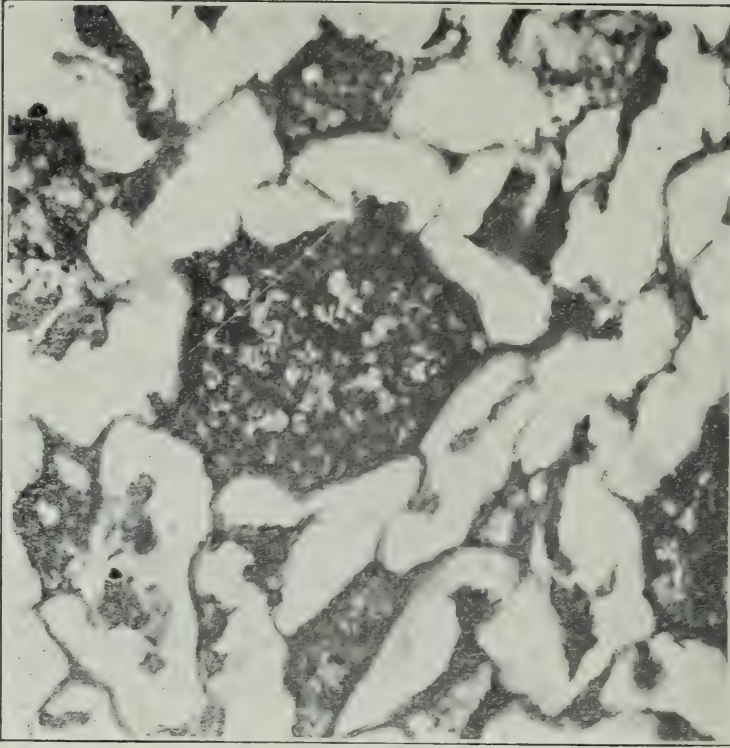


Fig. 12. Cross section of bark of diseased apple pedicel (same section as Fig. 11), showing cells filled with bacteria within a gummy matrix. X 1000.

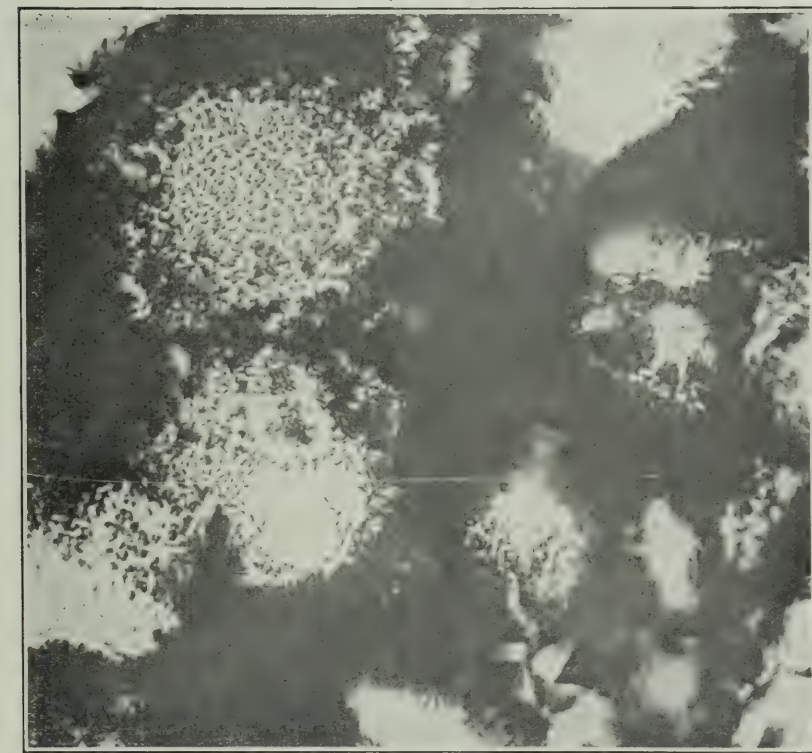


Fig. 13. Cross section of a diseased young apple, showing cells filled with bacteria—*B. amylovorus*. Section 4 microns thick, stained carbol fuchsin. X 1000.

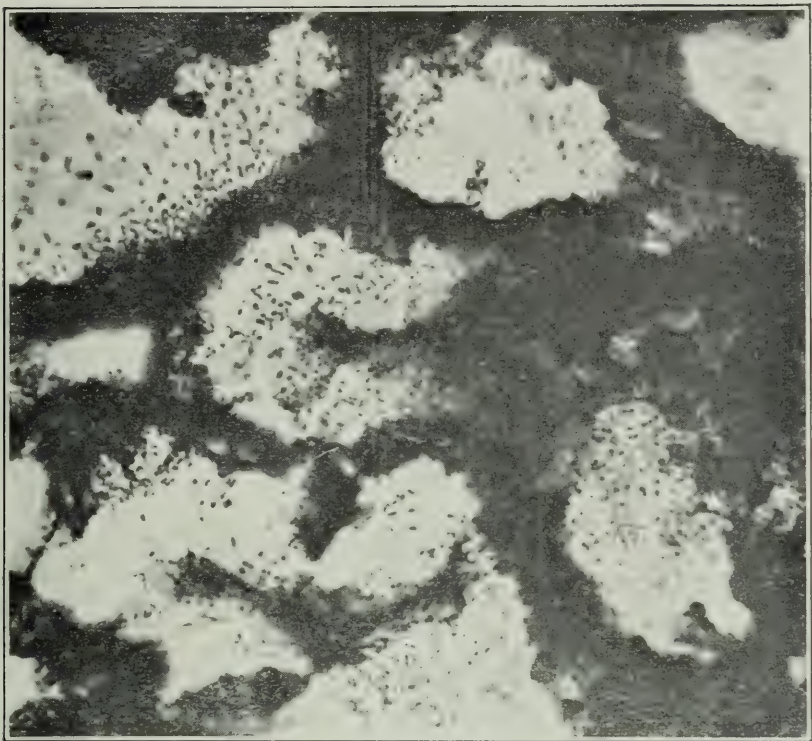


Fig. 14. Cross section of a diseased young apple, showing bacteria within the cells. Section 4 microns thick, stained carbol fuchsin. X 1000.

The disease usually begins at the tip of the twig or in the blossom and works downward. The bacillus lives in the cells of the inner bark, feeds on the cell contents, and, as it develops and multiplies, passes along from cell to cell destroying the tissue as it progresses. (Figs. 11, 12.) It may travel down the twig at the rate of from a quarter of an inch to two inches a day, the rate of its progress depending largely upon the succulency of the twig and the atmospheric temperature. The more juicy the twig, the more rapid the development, and warm days are more favourable to the progress of the disease than cold days.

On reaching the base of the twig, the disease may pass into the branch bearing the twig and from this point it may progress both up and down the branch. It often girdles the branch, and when such girdling occurs the flow of sap is prevented from reaching the upper part of the



Fig. 15. (a) Section of a young apple as it appeared one month after puncture inoculation with pure culture of *B. amylovorus* (see Exp. 11). The entire apple was diseased, brown, soft and saturated with a gray, viscid, slimy liquid, and teeming with bacteria. (b) Section of healthy apple (control, Exp. 11).

branch, which consequently slowly dies for lack of nourishment. (Fig. 47.) The appearance of the leaves, fruit, and bark of a branch so affected is different from that of the same parts on diseased areas themselves. The leaves slowly lose their green colour, the fruit slowly dries up, does not become decayed, soft, and pulpy, and the bark does not discolour and shrink so rapidly as does bark that is diseased. If a portion of diseased bark be stripped from the twig with a knife, the brown discolouration will be found to extend right through the bark and the surface of the wood itself is usually stained the same hue. The organisms will be found to extend in all directions within the bark some distance beyond the discoloured area.

II.—THE DISEASE IN THE FRUIT.

The disease is often found in immature, but seldom found in mature fruit. It may find entrance to the fruit by way of the peduncle from a diseased twig or fruit spur, in which case the disease would spread from the core outwards. Or it may find entrance by puncture of the skin by insect or other means, when the disease would work from without inward. Such cases have not been observed to be numerous, though some such were examined, and experiments in the laboratory showed that puncturing the skin of a young apple with a needle dipped into the gummy exudate from a diseased tree, or into a pure culture of the germ, resulted in the complete destruction of the fruit in from two to three weeks. (Figs. 15, 16.) Mere contact of the germ on the fruit, however, did not result in the development of the disease. Several ex-

(A)

(B)

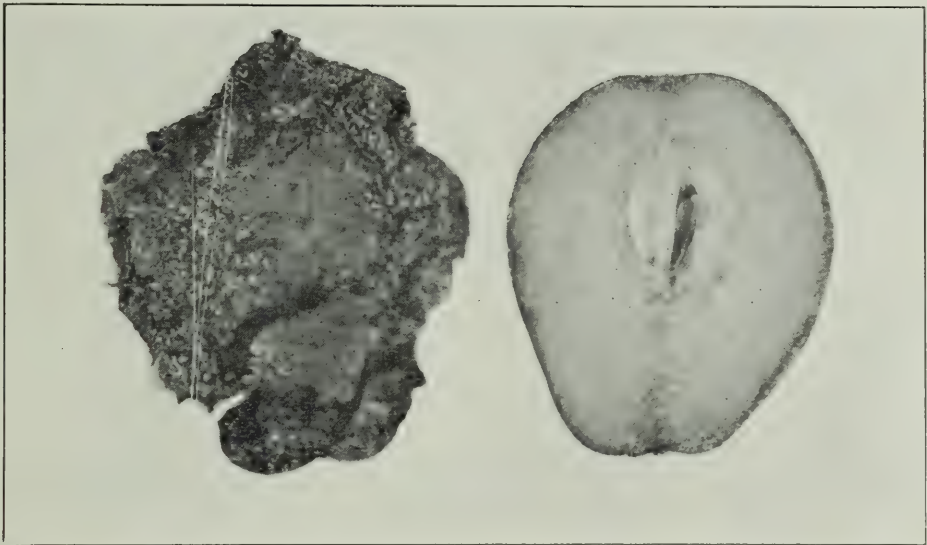


Fig. 16. (a) Section of a diseased young pear six weeks after inoculation with a pure culture of *B. amylovorus* (Exp. 11). The whole pear was brown, pulpy, decayed, and was cut with difficulty owing to its being so soft. The entire mass was filled with bacteria. (b) Section of a healthy pear (control, Exp. 11).

periments were made to test this possible means of infection, *e.g.*, the gummy exudate, and pure cultures of the germ were copiously smeared on the surface of sound fruits, but without success.

The exterior of a diseased young apple or pear will be discoloured light brown at first, then dark brown, and finally black. (Fig. 17.) As the disease progresses, the flesh will become soft and pulpy, and the skin will become somewhat wrinkled. (Figs. 15, 16.) If the fruit be sectioned, the diseased part of the flesh will be soft and present a slimy and decayed appearance, discoloured any shade of brown to black. Microscopic smear preparations of this broken down tissue or of the slimy fluid reveal dense swarms of the bacillus, and paraffin sections show the

cells to be impregnated with the germ. (Figs. 13, 14.) Sometimes this slimy liquid oozes through the pores or through insect punctures of the skin in the same way that the gummy exudate emerges from the diseased areas on the twigs, limbs or trunks of the trees. When so exposed, insects alighting on the fruit get contaminated with it, and, as it is crowded with the disease germs, when the insects fly away they carry the germs along with them, especially on their feet and mouth parts. The disease spreads rapidly in the tissue of a young fruit, but slowly in a fruit that is ripening. In the latter case the diseased area does not become slimy, soft and pulpy, but becomes discoloured brown, having

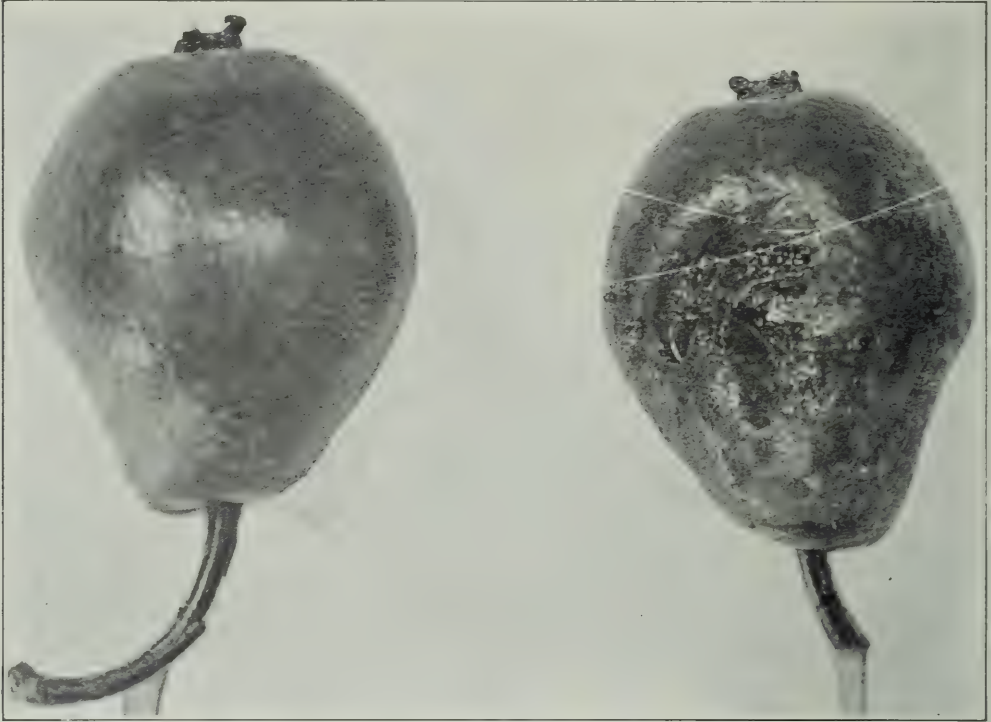


Fig. 17. Two halves of a diseased pear forwarded to the laboratory for examination. The flesh was brown, viscid, soft, and filled with *B. amylovorus*. Evidently the pear had been punctured and inoculated when young by some insect, within the sunken decayed area shown on the right half. Note the slimy liquid smeared on the background and trickling down from the stems. This was swarming with *B. amylovorus*.

somewhat the appearance of a bruise, but the discoloured tissue is no tough as is that of bruised tissue. (Figs. 18, 19.) As the spur, twig or branch bearing the diseased fruit dies from the disease, thus preventing the flow of sap to the fruit, such fruit slowly dries out, become deeply indented with wrinkles, turns black or dark gray, and dull, and becomes quite hard. Such fruit will often remain on the tree through the winter.

III.—THE DISEASE IN THE MAIN LIMBS AND TRUNK.

1. IN THE APPLE TREE. Where the disease occurs in the main limbs or trunk of the apple tree it is usually confined to a well-defined and limited area. (Fig. 37.) This is the phase of the disease called by Whetzel "Blight Canker." Fully 90 per cent. of such infections are due to twigs, water-sprouts, and suckers being primarily inoculated. (Figs. 20, 21, 22, 23.) Down these latter the disease progresses until it reaches their base from which it usually spreads in all directions within the bark of the larger growth. So long as suitable conditions are obtained in the older growth, the disease will continue to spread there.



Fig. 18. Section of a diseased ripe apple forwarded to laboratory for examination from British Columbia. The brown discoloured areas were not slimy, but were filled with *B. amylovorus*. Most of these diseased areas were near the outside, and externally the apple presented the appearance of being badly bruised. The shipper stated that a considerable number of so affected apples were in his district. Evidently it had been inoculated by insect punctures.

While the disease is active, the bark affected will usually be a little darker in colour than the healthy bark and will usually appear somewhat moist as if water soaked. Sometimes it will be slightly raised and, if there be plenty of sap in the bark, it will usually blister and the characteristic gummy matter loaded with the germs will exude. As

soon as unfavourable conditions obtain, as, for instance, a diminution of the sap supply which may be induced by lack of cultivation, drought, or cold weather, the progress of the disease is checked, the germs present consume all the food material in the affected area, and being unable to get more owing to the resistance of the surrounding tissue to their invasion, they gradually die out from lack of nourishment. When the disease ceases to be active, the affected bark shrinks and subsides, and in doing so it is torn from the healthy tissue surrounding it and a crack is thus formed, usually entirely encircling the dead portion.



Fig. 19. Section of a ripe Tolman Sweet apple, O.A.C. orchard. The dark areas near the centre were brown and filled with *B. amylovorus*. On the outside of the apple was a brown, somewhat sunken area, 2 in. x 1½ in. Part of this area was glazed over with a dry, gummy exudate, a large drop of which was still moist and adhering to the surface; this contained many bacteria. From this area the diseased tissue spread irregularly to the core.

When cut with a knife the diseased bark will appear brown, while the healthy bark surrounding it will be pale green or creamy white in colour, and the line of demarcation between these is usually sharp and distinct. The dead bark is very tough. Sometimes germs will have pushed beyond the well-defined cankered area and will remain alive but not very active in the apparently healthy tissue until favourable condi-

tions once more obtain, when they will resume their activity and another cankered area surrounding the old one will thus be produced. Sometimes a series of such cankered areas will develop, due to a repetition of the necessary conditions for growth, each crack separating one cankered area from the others representing the termination of a period of activity. Blight canker may develop at the base of the trunk, or crown, from infected suckers. One such case occurred in the College orchard this season.

2. IN THE PEAR TREE. As above intimated, while the disease does not cause so much loss by its development in the bark of the trunk and main limbs of apple trees as it does in the twigs and smaller branches of the same, with the pear it is the reverse conditions that prevail.

When once the germ finds entrance to the bark of a main limb or trunk of a pear tree, it seldom dies out until the whole tree is dead,



Fig. 20. Typical blight canker at the base of a water-sprout on the main limb of an apple tree, O. A. C. orchard. The water sprout had been inoculated by aphids coming to it from a diseased tree.

unless the diseased area is radically removed. (Figs. 7, 43.) Especially is this the case with the choicer varieties of pears—the Duchess, Bartlett, Flemish Beauty, Clapp's Favourite and Clairgeau, for instance. When once these trees are attacked they seldom live more than three years if the disease is allowed to have its way. It is generally recognized by pear growers, both in Canada and the United States, that the cultivation of these superior varieties of pears results in a dead loss to them financially because of the blight; hence their cultivation is very little practised any



Fig. 21. A blight canker, 16 in. x 9 in., at the base of a cluster of water sprouts on main limb of a Tolman Sweet, O.A.C. orchard. The water sprouts were inoculated by aphids.

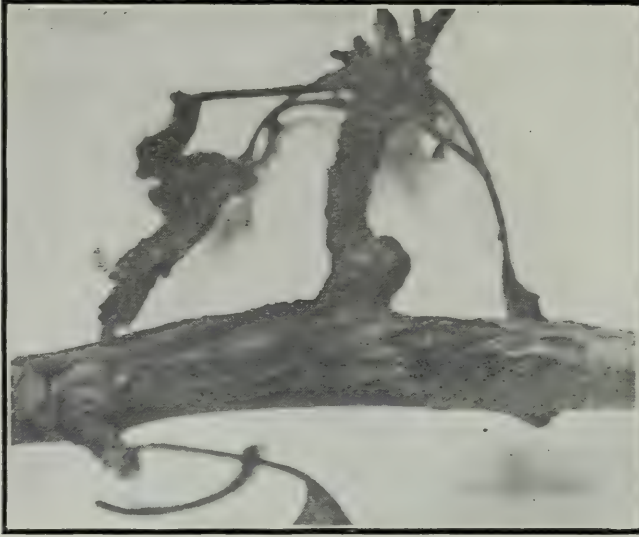


Fig. 22. Blight canker on apple twig at the base of a fruit spur which had been killed by the disease after being inoculated through the blossoms, O.A.C. orchard.

more, and such varieties as the Kieffer, which in texture and flavour is something akin to a turnip, and is not juicy enough for a bacillus to readily thrive in, is produced and put upon the market.

The disease develops and spreads in the main limbs and trunks of pear trees in much the same manner as in the twigs. The germ lives in the tissue cells of the bark, feeding on the cell contents. The exterior of the bark becomes discoloured, sometimes brown and sometimes purplish. It often blisters and cracks and amber-coloured gummy exudate emerges when the disease is most active. (Figs. 24, 25.) This may often be seen flowing slowly down the face of the diseased area. The disease is much less active during the winter than during the summer, though the complete cessation of its activity during the cold period

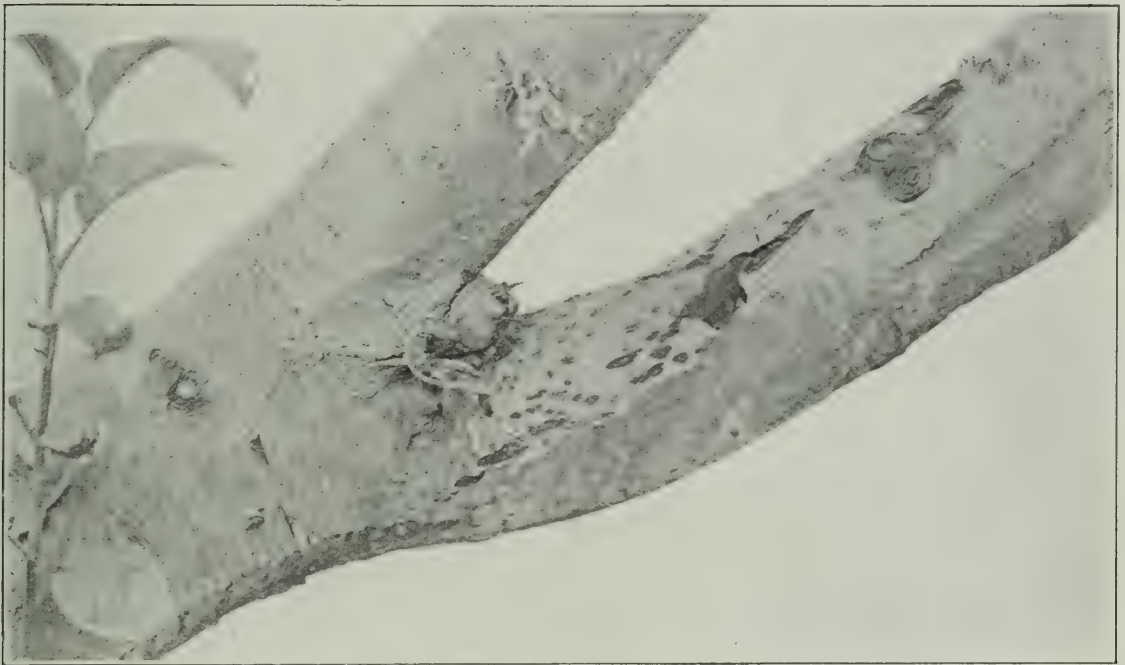


Fig. 23. Large blight canker rapidly spreading in crotch of main limbs of Romenskø apple tree, O.A.C. orchard. The whole of this canker developed in two months after inoculation by aphids through a water-sprout. Just above the centre of the picture is a small canker spreading at the base of a water-sprout also inoculated by aphids; and at the extreme right may be seen a long narrow sunken area running down the limb; this is a portion of a large canker formed at the base of a water-sprout, also aphid inoculated.

is questionable. In the spring the tissue surrounding the dead cankered areas is teeming with the disease germs, which, on the flow of sap, begin rapidly to develop and spread farther afield. The disease is irregular in its progress. It may spread in any direction, and the cracks mark its periods of activity, and may be longitudinal or horizontal, but are seldom oval or circular as in the case of the apple. These periods of activity vary in duration, depending somewhat upon

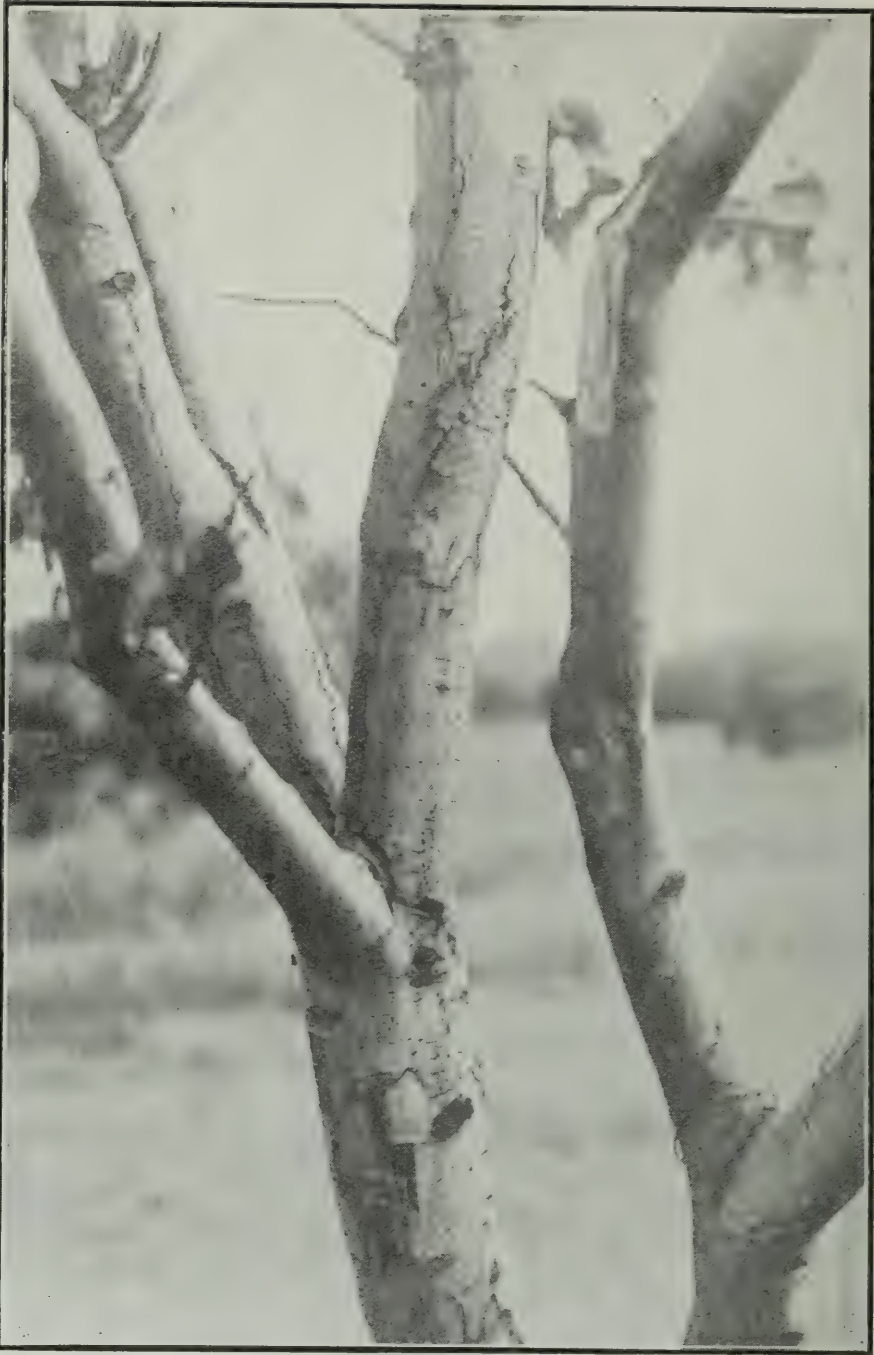


Fig. 24. Main limbs of a Flemish Beauty pear tree, O.A.C. orchard, in which the blight is rapidly spreading. The limb to the right is practically dead. Notice the cracking and blistering of the bark, especially on the middle limb. All the disease above the crotch developed this season from the cankered area below the crotch. It spread throughout the bark very rapidly during June, July and August. Photo taken in September.

climatic and soil conditions which regulate the flow of sap—more sap, more disease, if the germ be in the tree.

It is this fact that is responsible for the idea that so largely prevails among pome fruit growers, that orchards under cultivation are more subject to the blight than are orchards in sod. The trees in orchards that are fertilized and cultivated naturally produce more young growth, and are more sappy than those in sod, and this condition being the most favourable for the rapid development of the organism, should it be present in the trees, the spread of the disease in these trees



Fig. 25. Main limbs of blighted Flemish Beauty pear tree, showing the amber-coloured gummy liquid exuding from and trickling down the surface of the cankered area.



Fig. 26. Winter aspect of same tree as represented in Fig. 27. Note the leaves and fruit still adhering to limbs killed by the disease.

is much more noticeable than in trees that are less thrifty. Pear orchards may be in sod a number of years and the disease be present in the trees, but progressing so slowly as to be scarcely noticed by the owner. At length the owner decides to plough up the sod and cultivate. This results in the greater flow of sap in the trees, produces ideal

conditions for the rapid development of the disease, and before the season is over dead limbs and dead trees are seen in all directions. The owner, disgusted, destroys the dead material and allows the orchard



Fig. 27. Blighted Flemish Beauty pear tree, summer aspect. A dead limb was cut from the stub seen on the right in the spring. The dead limb to the left produced leaves this season which fell in June, owing to the complete girdling of the limb by the disease. The disease spread rapidly up the middle branches, which are those represented in Figs. 24 and 25.

to return once more to sod, deeming it better to have a decreased yield of fruit than to have his trees killed out wholesale. The spread of the

disease slowly subsides, falls to proportions in which it is not very noticeable, and the owner decides that the attack of the disease was due to the cultivation, which, of course, indirectly it was. A number of such cases have come directly before our notice.

Sod, however, is not an ideal condition for an orchard. It means a diminished supply and an inferior quality of fruit, and it is a nursery for numerous of our insect pests. This being the case, what is the pome grower to do? The best thing is to find a more direct method of attacking the blight than merely diminishing its spread by leaving the orchard in sod. If we can only find out the exact means whereby it is spread, and then directly, instead of indirectly, attack those means, we shall be in a fair way to a successful control of the disease. Our observations this season have resulted in establishing two specific agents in the spread of the disease—the aphid, *Aphis mali* and *Schizoneura lanigera* in the apple, and the fruit bark borer, *Scolytus rugulosus*, in the pear.

DISSEMINATION OF THE DISEASE.

The specific cause of the disease once being established, the next step is to find out its means of dissemination. Numerous theories concerning the spread of the disease have been promulgated both by scientists and by laymen. Mere theories, however, while they may be plausible are not by any means satisfactory, and unless substantiated by direct observation data are not reliable.

Some observers contend that the wind is responsible for much of the spread. They noticed that the disease progresses through the orchard in the direction of the prevailing winds. They have suggested that the gummy exudate dries on the outside of the tree, powders into dust, and in this condition is blown from tree to tree. While the argument sounds plausible, it has not been verified by experiment. Spores to enable it to tide over unfavourable conditions have not been observed in the organism under any conditions, and the organism soon dies on drying in the sun, as we have proven both in the laboratory and by outside observations.

BLOSSOM INOCULATION. So far as observed, insects are the principal means of dissemination. Nearly all the twig blight that is noticed in the spring is due to blossoms being infected. Bees, wasps, and other insects visiting the blossoms are said to convey the germ from flower to flower. Waite, of the United States Department of Agriculture, has found the organism in the nectaries of apple blossoms and also on the legs and mouth parts of bees. This evidence is sufficiently conclusive to warrant the statement regarding bees as carriers of the disease.

The question is, where do the bees in the first place get the contamination? As previously remarked, when the disease is in an active condition either in twig, bark or fruit, a gummy exudate loaded with germs is often found oozing through the epidermis of the affected part.

Insects alighting upon or feeding on this material would get contaminated with the germ and carry it away with them attached to their feet



Fig 28. Blighted water-sprouts from an apple tree, O.A.C. orchard. These were inoculated with the disease by aphids. Note the remains of the aphids all over the twigs, and especially the winged aphids on the leaf to the left ready to fly off to another tree, carrying the germs of the disease with them. Pure cultures of the germ were obtained from these.

and mouth parts particularly. We have found flies, beetles, aphids and other hemiptera feeding on or walking over this area. Though possibly

this is how the bee gets contaminated in the first place, the writer has never yet seen one alight on the gummy exudate, and in fact though careful search was made last season through the College orchard all through blossom time, no gummy exudate could be found on twig, branch or trunk of apple or pear tree. Later in the season, however, in the latter part of June, throughout July and August, when the disease was active, much exudate was observed on trunk, twig and branch of affected trees, and many trees were affected.

Notwithstanding the fact that no exudate was observed on the trees before or during blossom time, a large number of blossom infections occurred and subsequently developed in various parts of the orchard. If these inoculations were made by bees, from where did the bees get the germ, if there was no gummy exudate for them to come in contact with? We expect to work more on this phase of the subject next season if possible.

So much, then, for blossom infection. The germ has been found in the nectaries of the flowers and has been found on the proboscis of bees visiting these flowers. But the germ will not develop in the nectaries until it is deposited there. Here our positive knowledge of this phase of the subject ends.

TWIG INOCULATION. The term twig inoculation is here applied to twigs affected by means other than through the blossom. It seems to be generally thought that all twig infection is through the blossom. The writer concludes thus as he has not seen any reference in literature dealing with the disease that says anything to the contrary. For several seasons we have casually noticed in various parts of the country numerous twigs affected that had no blossoms on them, or in some cases anywhere near them. This was particularly so in the case of apple trees. The question arose in our minds as to how these twigs became infected.

During the past season this phase of the disease was first noticed on July 1st. The first specimens observed were a few water-sprouts on the main limbs of a mature Spy apple. The tree was in sod, had been well scraped over the previous fall and sprayed during the spring. No disease was found on any other part of the tree than on these water-sprouts. How did it get there? There were no blossoms on the sprouts as they were largely of this season's growth, hence it was improbable that bees had caused the inoculation. The means of inoculation, however, were readily apparent. *The sprouts were covered with aphids and aphid remains.* The tips of the sprouts that were dead were covered with the remains of aphids, and the leaves and stems that were still alive were dying from the disease and were covered with living aphids, and many of these were of the winged form. The sprouts were taken to the laboratory, photographed (Fig. 28), and pure cultures of the germ were obtained from them.

Every horticulturist is more or less familiar with the aphid and its injuries to trees. The aphid is a sucking insect. It obtains its food by puncturing the tender bark of young shoots and leaves with its



Fig. 29. Cluster of water-sprouts on apple tree in which the blight is rapidly spreading, being carried from twig to twig by the aphids.



Fig. 30. Water-sprouts on apple tree in similar condition to those shown in Fig. 29.

proboscis through which it sucks the plant juice. It reproduces very rapidly. Hitherto it has been thought that the extent of the damage which it caused was confined to the direct injury done to the plant by depriving it of sap and the malformations caused by the irritation set up in the area attacked. Our observations this season, however, have proven conclusively that the great majority of the new infections of twigs by the blight after the blossom season has closed are due to the transmission of the germ from diseased areas by aphids.

In the College orchard are over three hundred apple trees, and more than one hundred pear trees, and these were under close surveillance all through the season, and numerous other orchards about the Province were visited. In all instances the same facts were elicited. We will cite a few individual cases.

Fig. No. 29 is a Tolman Sweet apple tree in the College orchard. Previous to the arrival of the aphids early in July there was no blight on the tree. During July the aphids (*Aphis mali*) were very numerous on the young growth of this tree, as they were on many others in the orchard. The tree was frequently examined and the spread of the disease was coincident with the spread of the aphids about the young growth. In a number of cases the disease entered the limb at the base of the water-sprout and there formed a small canker. The water-sprouts being very tender and juicy, they formed an ideal feeding ground for the aphids and were also an ideal medium for the rapid development of the disease when once inoculated. Within a week all stages of the disease were evident. Some sprouts were brown, shrivelled, and dead with dried gummy exudate and the remains of aphids still adhering to them. In others the disease was very active. In practically every case it had commenced at the tip, evidently the first part attacked by the aphids, for invariably it was there that the remains of aphids occurred in abundance, while the living specimens were to be found further down the sprout. The tips of such would be dark brown and shrunken and curling over, while further down the gummy matter would be often noticed exuding, and this on frequent microscopic examination, revealed the germs in characteristic abundance.

Fig. 31 represents a Tolman Sweet stock on which were a number of grafts of different varieties. These grafts were three years old, and had developed a dense bushy growth of twigs. Previous to the arrival of the aphids at the end of June, there was no blight on the tree. Soon after their advent the blight appeared, and as they increased in numbers and spread over the tree the blight spread also, until at the end of August fully ninety per cent. of the young growth was killed out by the blight. In several cases the disease had entered the stock, and in one instance a canker four inches by six inches had developed by September. In addition to the top of the tree being killed out, the whole of the dense sucker growth at the base was destroyed by the blight, not one single sucker being left alive. Fig. 32 represents the tree on September 10th when the dead tissue was cut away.



Fig. 32. Same tree as shown in Fig. 31 after having the diseased material cut away in September.



Fig. 31. Tolman Sweet stock on which numerous grafts had been made. Note about 95 per cent. of twigs blighted.



Fig. 33. Young apple tree, Vandevere, showing blighted twigs, all of which were inoculated with the disease by aphids during June and July.

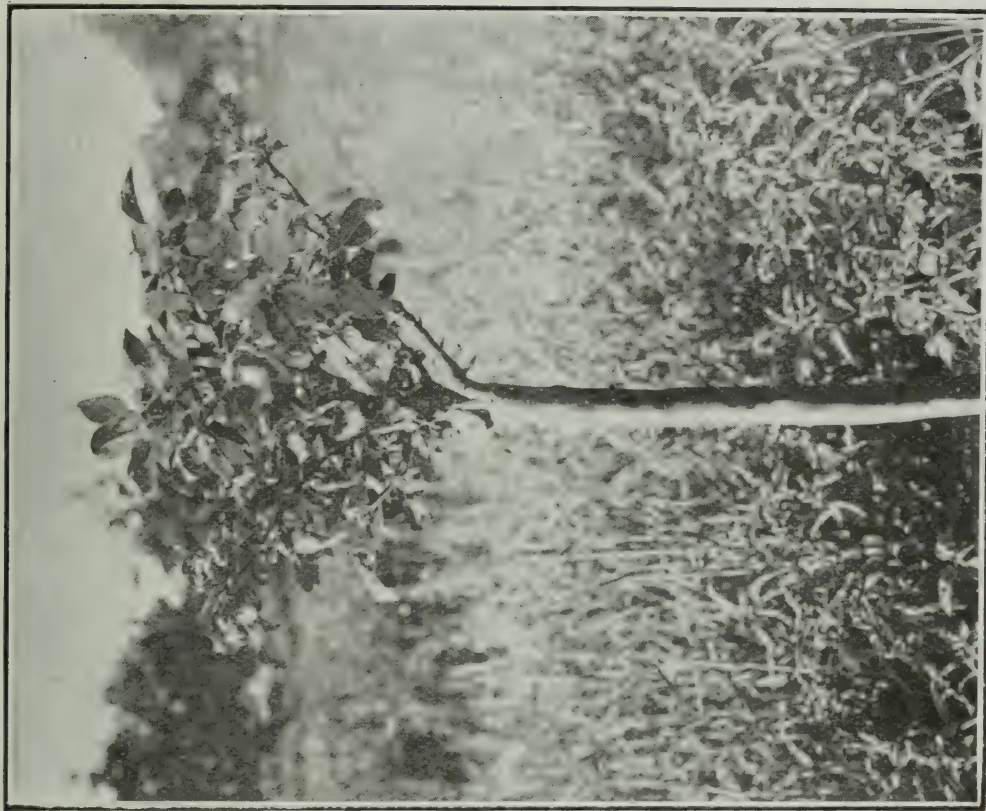


Fig. 34. Same tree as shown in Fig. 33, with the diseased twigs cut away in August in order to save the tree.

Fig. 33 represents a young Vandevere apple tree four or five years old. No blight was on this tree before the aphids settled upon it. With their arrival the blight commenced, and by the first week of August fifty per cent. of the young growth was killed out. At this date, in order to preserve the tree, the diseased tissue was cut away, and Fig. 34 represents the tree after such pruning.

Fig. 35 represents a Benoni apple tree that had no blossoms this season. No blight developed on it until July when it was attacked by



Fig. 35. Head of a Benoni apple tree in which 50 per cent. of the twigs blighted after being inoculated with the disease by aphids.

aphids on the water-sprouts near the base of the main limbs. Here the disease first developed. The tree had been pruned cup-shape to allow the light to get in to the interior. By the middle of August more than a hundred twigs, all of which were on the inside of the tree, were blighted. The aphids had passed from twig to twig on the inside of the tree and carried the germs of the disease wherever they went. All the sucker growth at the base of the tree also developed the blight after being attacked by the aphids.

Fig. 21 represents a canker on the main limb of a Tolman Sweet apple tree that developed this season at the base of a cluster of watersprouts after these were attacked by aphids. The disease passed down the sprouts into the bark of the limb, and the limits of its most active period are readily distinguished by the encircling crack which separates the dead from the living tissue.

Dozens of such cankers were examined and all traced to a similar beginning.

Orchards in the Niagara, St. Catharines, Grimsby, and Winona districts were examined where similar cases in abundance were observed.

A mature apple orchard at Fruitland belonging to Mr. J. Tweddle was examined on September 14th. Mr. Tweddle had taken great pains to remove all blight during the pruning season. The trees had been well sprayed with Bordeaux in the spring and early summer and were in splendid condition. In the examination scarcely any blossom infection was apparent, but dozens of trees were found on which watersprouts and this season's twig growth had been killed out by the blight, and all these upon examination bore evidence of aphids, and in many cases the woolly aphis (*Schizoneura lanigera*) was still present in considerable numbers, clustered in the axils of leaves and fork branches and in crevices of the bark. In all probability, the aphids had in the first place come in contact with the disease in the environs of the orchard, for the blight was prevalent all through the district, not only on the fruit trees in the orchards, but we observed it on the hawthorn bushes along the roadsides as well.

SPREAD OF THE DISEASE IN THE NURSERY.

In the apple nursery of Mr. E. D. Smith, Winona, there were some thousands of young seedlings. Very few of these were affected with the blight. A dozen or so cases were observed, but the percentage was very low. On being questioned concerning the prevalence of aphids among the nursery stock, the manager stated that owing to constant supervision the aphids had very little chance to make headway. Kerosene emulsion was always on hand, and as soon as aphids were noticed on the stock, every young tree affected was immediately dipped in the emulsion. Hence, by keeping the aphids in check the disease had been kept from spreading in the nursery. The disease was prevalent in the immediate vicinity of the nursery in every direction. At one end of the rows of apple seedlings was a bunch of about two hundred young Kieffer pear trees heeled in ready for transplanting. Every one of these was badly blighted, the majority being rendered totally worthless, and the manager said that nothing could be done with them other than to burn them all just as they stood bundled together. At the other end of the rows ran the public road, and on the opposite side of the road were apple trees very badly affected with the blight, and hawthorn trees



Fig. 37. Old blight-cankered area on limb of Romenskoe apple branch. This canker extended three feet eight inches along one side of the branch, almost girdling it in two places. The dead bark was shelling off. In places saprophytic fungi had found entrance to the heart wood, thus hastening the decay of the branch.

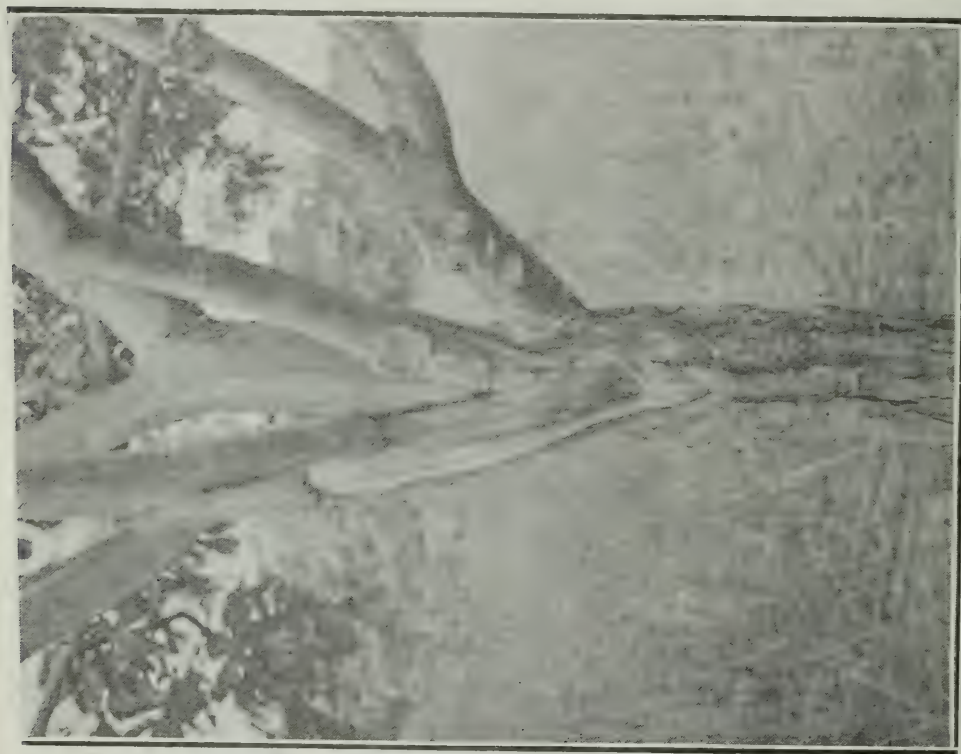


Fig. 36. Wound on main branch of a Romenskoe apple tree where the bark, after being cankered and killed by the blight, has been cut away to save the tree. The exposed wood was painted with a thick coat of white lead to prevent entrance of saprophytic fungous spores.

also similarly affected. So that the absence of blight among the apple seedlings was not due to there being no blight near them, but rather to the destruction of the means of transmission, *i.e.*, the aphids, as soon as they appeared.

At other nurseries that have come before our notice, little, if any, attention was paid to the aphids, which were abundant, and in these nurseries blight was excessive.

From our observations we have concluded that practically all the fresh nursery infection, all the water-sprout infection, all the sucker infection, all the twig infection other than that due to blossom inoculation, on the apple trees was due this season to inoculation by the aphids, and we infer from this that probably it is usually so. This season the aphids was very plentiful and the blight was proportionally so. Possibly the periodic bad outbreaks of blight in the apple are coincident with a plague of aphids such as occurred this year.

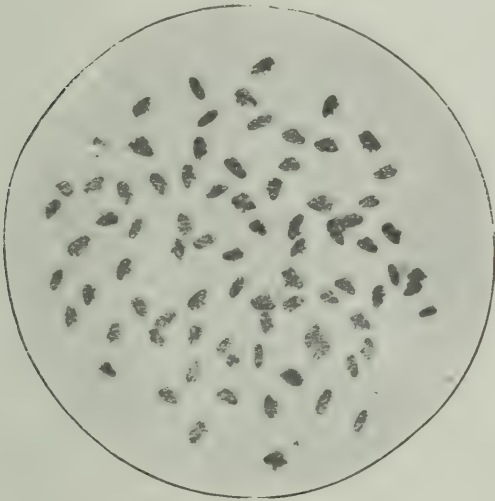


Fig. 38. Fruit bark boring beetles (*Scolytus rugulosus*) picked off the bark of a diseased Bartlett pear tree, the tree shown in Fig. 7, the bark of which was badly riddled with their shot-hole borings. (Natural size.)

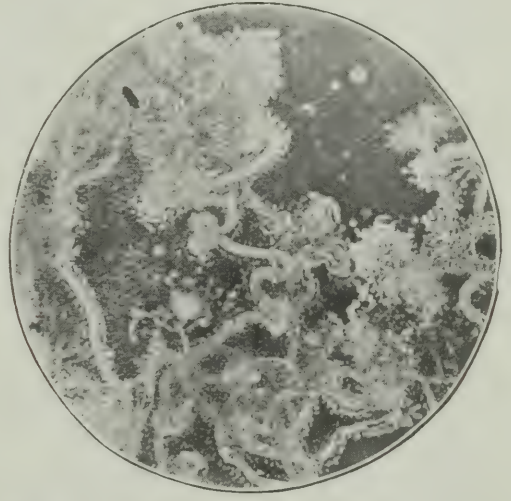


Fig. 39. Agar plate cultures of bacteria which developed in the track of the fruit bark boring beetle seen natural size in the upper left hand of the picture. About 65 per cent. of this bacterial growth was *B. amylovorus*. The beetle was obtained from a blighted Bartlett pear tree with sterile forceps.

SPREAD OF THE DISEASE AMONG PEAR TREES.

The aphids, however, is not found to any extent upon the pear tree. On the other hand, as already stated, neither is twig blight very common on the pear except where it occurs as the result of blossom inoculation, and this is not nearly so common as on the apple. How, then, is the disease carried from tree to tree in a pear orchard?

Any boring beetle or any biting or sucking insect frequenting pear trees may act as carriers of the disease. We have been able to trace to

one species of the boring beetles, *e.g.*, the fruit bark borer (*Scolytus rugulosus*), several cases. While inspecting a diseased young Bartlett pear tree in the College orchard one bright sunny day in June, we noticed a number of fruit bark borers emerge from their holes and run about on the surface of the bark. Some of these were caught in sterile test tubes and brought to the laboratory. Several gelatin and agar plates were prepared and when set, one of the beetles was allowed to run about on the surface of each. The plates were then incubated. All of them produced copious bacterial growth along the tracks of the beetles. Of this growth, from thirty to seventy-five per cent. was of the blight germ, *Bacillus amylovorus*. One of these plates is represented in Fig. 39.

On another occasion, the 16th of September, while examining the pear trees in Mr. E. D. Smith's orchard at Winona, we met with the same species of beetle in healthy young growth on a mature Bartlett

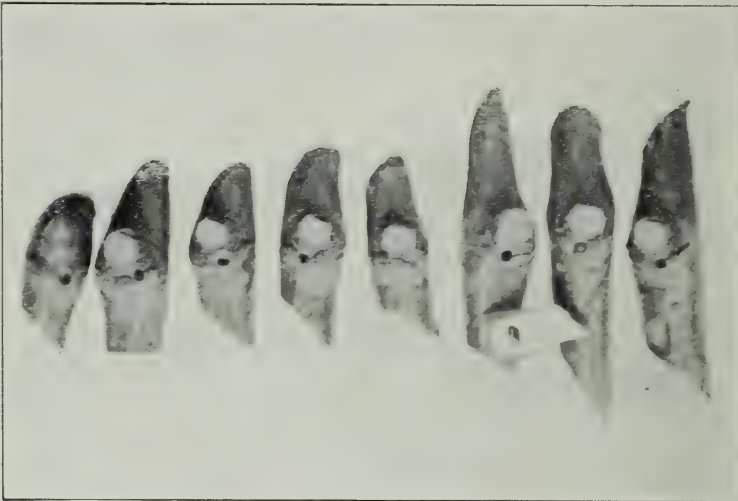


Fig. 40. Cuttings from a healthy Bartlett pear branch that was perforated immediately below each of thirty leaf or fruit spurs by the fruit bark boring beetle. In every hole was a beetle and the bark surrounding the eight represented was developing blight. (Natural size.)

pear tree. On the under side of thirty out of forty leaf spurs on the branch were the characteristic round shot-hole borings of *Scolytus rugulosus*, and in nearly every hole was an adult beetle. In the region of eight out of the thirty punctures, the blight had slightly developed with the characteristic changes in the bark. About eighteen inches further down the branch from the last of the series of punctures in the healthy part of the limb was a small cankered area in which were also two borings of the same nature. Whether this cankered area was the result of inoculation by the beetles making the borings, or whether the borings had been made subsequent to the development of the canker

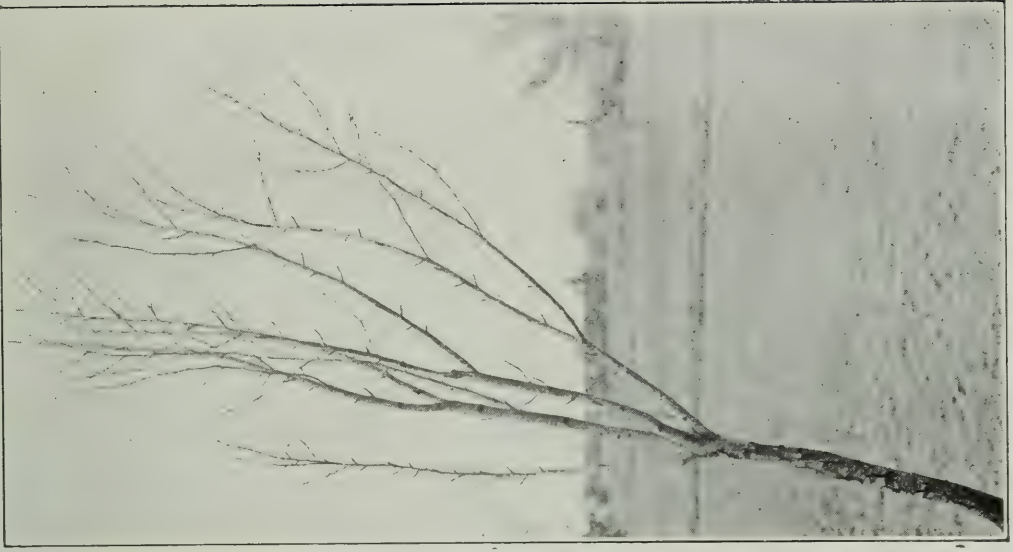


Fig. 43. Young Bartlett pear tree killed by blight. The branches shown in Figs. 41 and 42 were taken from this tree.

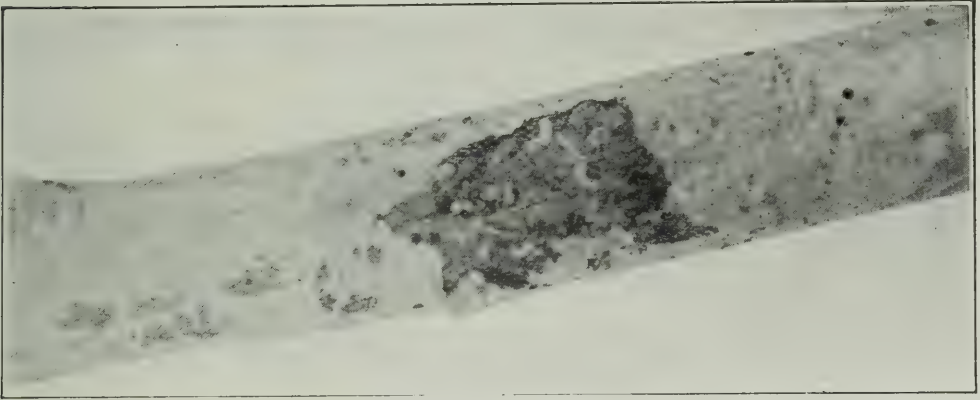


Fig. 42. The same branch with a portion of the bark removed to show the white larvæ in September. (Nat-

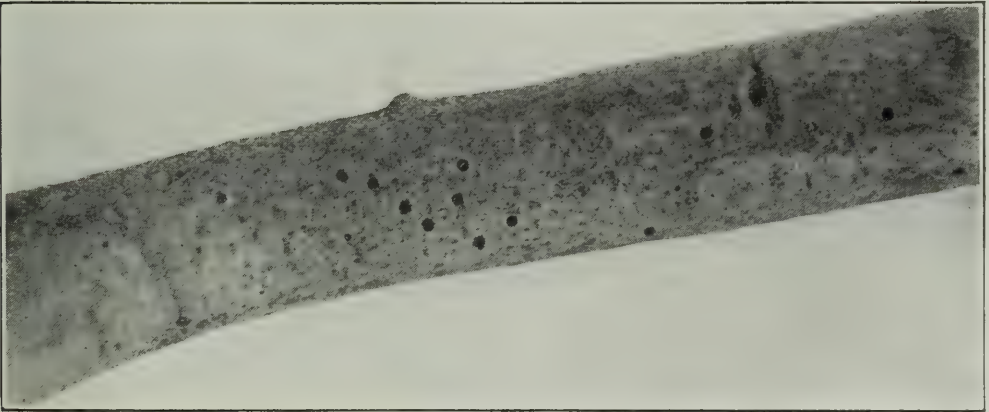


Fig. 41. Dead branch from a Bartlett pear tree, killed by blight, showing the borings of the fruit bark boring

was not decided. The canker, however, was in an active condition and was of recent development. The tree was otherwise free from disease.

On making another examination of the afore-mentioned Bartlett tree in the College orchard (Fig. 43) on September 20th, it was found to be practically dead. Nearly all the leaves had fallen, and what remained were pale yellow or brown. The tree had suffered badly from the blight in the trunk the previous season, which had so lowered its vitality that the foliage this season never looked healthy and vigorous, and as the disease continued to spread in the trunk this spring and early summer the tree gradually succumbed. During this time the beetles had made numerous perforations in the bark of the trunk and larger limbs, and Fig. 41 is a representation of one of the latter. Fig. 42 is a representation of the same portion with some of the bark removed. Here



Fig. 44. Fruit bark boring beetles (*Scolytus rugulosus*) enlarged.

are seen the larvæ of the beetle. These larvæ were numerous in different parts of the tree.

Dr. Bethune and Messrs. Jarvis and Caesar of the Department of Entomology, O.A.C., were interviewed for information regarding the beetle, its habits and occurrence. They stated that it is very common on, and destructive to, both sour and sweet cherry trees, peach, plum, and apple trees, but they had not noticed its prevalence on pear trees. In the case of the cherry and peach trees it attacks them often in great numbers, causes a plentiful discharge of gum from the perforations, and often results in the destruction of the tree. This gum is very noticeable on the cherry and peach trees attacked; in fact, it was its presence which caused the investigations that finally led to the discovery of the beetle as the origin of it. In the case of the beetles' attack on the pear trees observed, there was absolutely no sign of any gummy material except where the blight was active in the bark. And, in every instance where

the beetle occurred in the healthy bark of a branch it was on the under side of a leaf spur, and the perforation was so small that one had to look carefully to perceive it. Possibly for this reason it has largely escaped the observation of entomologists.

Chittenden, in Circular No. 29 of the United States Department of Agriculture, 1898, states regarding the fruit bark boring beetle that, "In addition to the trees already mentioned as subject to its attack, available data indicate that pear is also quite subject to infestation, and apricot, nectarine, and quince trees are known to have harboured this species, while in Europe the mountain ash and the hawthorn are also recorded as being subject to its attack."

In Bulletin 19, new series 1899, of the United States Department of Agriculture, Division of Entomology, occurs the following on the fruit-tree bark beetle:

"May 16, 1898, Prof. E. A. Popenoe wrote from Topeka, Kansas, that in search for trees attacked by this species in different portions of Kansas many rows of trees were examined, and *in nearly every tree affected the top was blighted or a stump remained whence a blighted branch had been cut.* Beetles were also noticed in pear trees whose leaves were coloured so as to indicate ill health and were found to be also diseased at the root below the budding point. Many of the diseased trees showed the beetles just beginning work, precluding the possibility of the appearance of the disease resulting from the beetle attack. *In a few trees, however, the beetles were found at work where there was no sign whatever of ill health in the tree attacked.*"

Popenoe was studying this species of beetle and not the blight, and he found the beetles more often in diseased trees than in healthy ones. But he did find them in healthy ones. He found also that nearly every tree affected by them was blighted. He evidently concluded that the spread of the blight was responsible for the spread of the beetles. May not the reverse of this be true, *i.e.*, the spread of the beetles responsible for the spread of the blight. In the light of the above observations and experiments we venture to think that it may. There is, however, much room for more investigation on this part of the subject.

The facts, then, concerning the fruit bark boring beetle (*Scolytus rugulosus*) as a means of spreading the blight in pear orchards, are:

1. It has been found within and beneath the bark of both diseased and healthy trees.

2. Beetles caught issuing from their burrows in blighted trees have shown the presence upon their bodies of immense numbers of blight organisms when they were allowed to walk over the surface of gelatin and agar plates. Fig. 39.

3. Beetles have been found in what was to all appearance, sound, healthy, vigorous pear bark before their entrance, but which has developed a limited though spreading blighted area in the immediate vicinity of their boring.

We conclude, therefore, that the fruit bark boring beetle (*Scolytus rugulosus*) is one means of spreading the blight in both apple and pear

trees. As the blight is also common on the mountain ash, hawthorn and Juneberry, three other trees subject to the attack of the beetle, it is possible that the beetle is responsible for some of the disease there found.

OTHER MEANS OF SPREADING THE DISEASE.

The pruning-knife, saw, chisel, shears or other workman's tool used in the orchard, after having come in contact with a diseased tree is a very potent carrier of the disease. We have proved this experimentally by using a knife and a saw on the diseased part of a tree and then on a healthy tree, nicking the bark or cutting off branches, and in about seventy-five per cent. of the experiments the healthy tree contracted the disease at the point where cut. Both pear trees and apple trees were so experimented on.

Scraping healthy trees with diseased trees when removing the latter from the orchard usually results in infection of the former. A striking instance of such infection came before our notice in the orchard of Mr. E. D. Smith, Winona. While making an inspection of the orchard in company with the manager we noticed a mature Bartlett pear tree standing isolated, no pear trees being anywhere near it. Just one of the lower limbs of this tree was blighted, and the foliage on this limb was dark brown or rapidly turning that colour. All the other foliage on the tree was bright green, vigorous and healthy, and no other sign of blight was observed on the tree. On making a close examination of the affected limb, we noticed that the underside of the lower extremity was bruised, some of the bark having been torn away, and this was the centre of the diseased area. When the manager was asked how long he thought it might be since the bruise had been made, he said it looked as if it had been done the fall before. When asked if there had been any diseased trees near, against which a waggon might have bumped and thus become smeared with the germ and then rubbed against the healthy tree, thereby inoculating it, he replied that the year before, the tree formed one of a row of Bartlett pears, and that all but it, which was the end one of the row, had developed the blight very badly, and in the fall all the diseased ones had been hauled out. Here then, evidently, was the means of infection. One of the diseased trees in being hauled past the healthy one had scarred this one limb, and left some germs in the wound. These penetrated the bark tissue, wintered over, and developed the cankered area during the summer, finally girdled the limb, and this cutting off the supply of sap to the upper part caused it to turn brown and die as described.

ERADICATION AND PREVENTION OF THE DISEASE.

The eradication of a bacterial disease from a district, whether it be a disease of man, animals, or plants, usually appears to be a difficult matter. The difficulty, however, is limited to the taking of necessary precautions to ensure a thorough destruction of all the germs of the

disease within that district. The precautions necessary to prevent the spread of and to destroy the germs of such diseases as cholera and typhoid fever in man, anthrax in cattle, hog cholera in swine, are now familiar to almost everybody. Of course, it means a great deal of work and trouble for those concerned, but this positively cannot be avoided, and the effectiveness of the work is proportionate to the thoroughness with which it is conducted.

The apple and pear blight at present is confined to the North American continent. No cases have ever been reported from any other country. Arguing from the point, no germ, no disease, what is needed to stamp the disease out of existence is simply to destroy all the blight germs in the country. This, however, is practically an impossibility, for the necessary concerted action on the part of all those growing fruits liable to the disease is practically impossible to obtain. However, concerted action on the part of all resident in a given district will be sufficient to so reduce the disease in that district that its presence will scarcely be noticed if it is not indeed entirely stamped out.

In the first place, let it be clearly understood that when once the disease enters a tree whether it be in fruit, twig, branch or trunk, there is no remedy for the affected part. The only measure to be adopted is to cut out and burn it right away. To cut off an infected twig will save the limb on which it grows; to cut out an affected large branch will save the trunk; and if the trunk be affected in only a limited area, the removal of the entire affected area will save the tree.

In cutting dead or diseased tissue from a tree, care must be taken to cut from six inches to a foot below the blighted area of a branch, and from two to four inches around a canker on a main limb or trunk. As previously pointed out, the germs are usually not confined to the visibly cankered area, but are penetrating within the bark in all directions for some distance beyond it. If only the visibly cankered area be removed these germs are still left in the tree, and the disease will continue to progress in the limb from which the cankered area was cut.

Some remarkable instances of such development came before our notice during the season. To quote one: Mr. Onslow, whose fruit farm is at Niagara-on-the-Lake, informed us, while visiting his farm on May 20th, that blight developed on most of his pear trees last fall. Every variety, one of which was the Kieffer, the most resistant variety, was affected. During the fall he cut out all the blight that he could find. Some of the trees were young and were so badly affected in the top that they were cut back right to the stump. Others that were more mature had limbs of various sizes removed.

Mr. Onslow is careful and thorough in his work, and he felt sure that he had cut out the disease entirely. However, when we examined the trees on May 20th, we found forty or fifty per cent. of them with the disease still progressing below the part cut. The disease had continued to spread below the cut area during the fall until the cold weather stopped it. When the warm weather of spring had started the sap again, the disease recommenced. The spring development of the

disease was readily distinguished from that of the previous fall. The latter showed the bark cankered, brown, dry, shrunken and separated from the former in many cases by a crack. The spring development of the disease showed the bark discoloured purplish to dark brown, somewhat swollen and somewhat moist in appearance. Mr. Onslow immediately cut these trees again eight inches to a foot below the visible affected part. Four of these pieces were brought to the laboratory, and we obtained pure cultures of the blight germ from every piece. When we again visited his farm in September no sign of the disease was found in any of these trees.

It is not advisable to do the regular pruning while cutting out blighted wood. There is the danger of carrying the germ on the tools used if they by any chance come in direct contact with the diseased part. Further, it is very desirable that the operator have with him a liquid disinfectant with which to swab the exposed cut surface, and also the tool used for cutting before it is used again on another limb. Formalin will do very well for such work, as it will not injure the steel tools. It may be carried in a bottle well corked, and a handy swab may be made by pushing a stout wire through the cork and wrapping a bit of cotton around the end that is to be inserted in the bottle.

The best time to cut out blight is the first time it is seen. Every case of active blight is a potent source of infection for innumerable other cases. However, it is not always practicable to locate every case of blight as it occurs. The best time for systematic action in an orchard is in late fall or early winter. At this time the diseased parts are more readily distinguished than in late winter or early spring, and if precautions be taken to burn the material cut out, this will insure the destruction of the beetles, aphids, and other insects harbouring on and in it.

We wish to lay special emphasis on the necessity for burning the diseased, dead, and cut away material in an orchard immediately after it has been cut. If dead trunks and large limbs of fruit trees are cut up for firewood they should be burned during the first winter. If they are allowed to remain until spring there is great danger of their sending out swarms of the fruit bark boring beetle which had wintered over in the wood in the grub stage. Mr. Caesar has recently traced several bad outbreaks of this borer in different cherry and peach orchards to such a source, and we infer from this that if they will do this with the cherry and peach they will do it with the pear. Figs. 41 and 42 show this inference to be warranted. The whole of the tree from which this branch was taken was riddled with such holes, and beneath the majority of these holes were larvæ of the beetle preparing to emerge in the spring as adults and make their way to other trees.

If an orchard be cleared of its blight during the winter as above indicated, there will be no germs there the following spring for insects to get contaminated with, and hence as the insects go from tree to tree they will not infect the blossoms. The blossoms not being inoculated, there will be no early twig blight, so that when the aphids come later in the season there will be no source of infection for them; and hence the

only damage they will do the trees which they visit will be to rob them of their sap which, as orchard men know, is bad enough, but is nothing compared with the blight. If, however, there are affected trees in the neighbourhood of the orchard, which is usually the case, then the only way to keep the disease out of the orchard is to control the insects.

Not much can be done with regard to controlling the bees. In some of the Western States there has almost been war between the fruit men and the honey men over this problem. It is not, however, the tame bee alone that is responsible for the dissemination of the disease among the blossoms, but the wild bees, wasps, ants, and other flower-visiting insects are equally guilty. Of course, spraying during blossom time would check this, but the law will not allow such measures because of the danger to the honey industry.

With the aphids, however, it is very different. They are lawful enemies at all times. Some fruit men contend that they are as great a pest as the codling worm, that is, when only their direct injury to the tree is taken account of; but when we add to this the damage they do by spreading the blight, their liabilities are increased a hundredfold. Hence the added necessity of keeping the aphids in check. Mr. Caesar recommends for their destruction spraying in spring, when the buds are just beginning to swell, with home-boiled lime-sulphur, preferably of the strength of twenty-five pounds lime, twenty pounds sulphur, to forty gallons of water. This is to kill the eggs which may be seen on the twigs and smaller branches of the tree. As it is seldom possible to destroy all the eggs by any wash, it will be wise to observe the buds as they are bursting and see whether any of the little green insects are present. If so, use kerosene emulsion of the ordinary strength for summer wash. To get good results, thorough work must be done. In the fall of the year observe if any aphids are present on the water-sprouts, where they will be found if they are on the trees at all at this time of the year. If present, cut off the water-sprouts and destroy them.

ORCHARDS INSPECTED.

I. ORCHARD OF THE ONTARIO AGRICULTURAL COLLEGE, GUELPH.

This orchard, though lying outside the recognized fruit growing sections, is capable of producing good crops of apples and pears of numerous varieties. It is used almost altogether for experimental work, variety tests, etc., and was kindly placed at our disposal by the Horticultural Department of the College for experimental purposes in connection with the blight.

The subjoined schedule, which was carefully filled in according to our directions by Mr. Cooper, orchard foreman, records full particulars of the number and varieties of trees in the orchard, all cases of blight which developed, and the nature of the attack, *i.e.*, whether inoculation occurred through blossom, twig, water-sprout, sucker, or body of the tree.

Apple trees.	Total number of trees.	Number infected.	Percentage of blossom infection.	Percentage of twig infection.	Percentage of water-sprout infection.	Percentage of sucker infection.	Canker on main limbs or trunk.	Remarks.
Alexander	7	4	(1) 50 (1) 25 1 20	25	.....	25, 2 trees on limbs	2 trees. 3 trees, very severe attack via bloom inoculation.	
Benoni.....	2	1	.....	50	25	90	on limb.....	Developed between 1st and 31st August from bad aphid attack. Gummy exudate from cankers.
Brockville Beauty.....	1	1	.....	5	.....	.....	.....	Bad aphid attack on water sprouts.
Canada Baldwin	3	2	.....	.....	10	.....	.....	This variety seems very liable to attack. Bloom inoculation very severe on all trees.
Champion	1	1	.....	.....	3	.....	.....	Aphid attack on new growth.
Colvert.....	5	4	70	5, 1 tree	10	10	limbs, 2 trees trunk, 1 tree.....	Aphid attack on new growth.
Coxe's Orange	1	1	.....	3	.....	.....	.....	Aphid attack on water-sprouts.
Duchess	8	7	.....	3	20, 7 trees	.....	.....	Aphid attack on new growth.
Early Harvest	2	2	.....	3	2, 1 tree	3, 1 tree	.....	Aphid attack on new growth.
Fallowater	5	3	.....	2	10	5	.....	Aphid attack on water-sprouts.
Fameuse	23	4	10, 1 tree	.....	20	5	.....	Aphid attack on water-sprouts.
Jones Fameuse.....	1	1	.....	.....	3	.....	.....	Aphid attack on water-sprouts.
Fall Jenetting	3	1	.....	2	.....	.....	.....	Aphid present.
Fall Pippin.....	3	1	.....	3	.....	.....	.....	Aphid present.
Fanny.....	3	1	1	1	.....	.....	.....	Aphid on new growth.
Garden Gem.....	1	1	.....	4	.....	.....	.....	
Gano	3	1	2	.....	.....	.....	.....	
Gideon	3	2	.....	.....	.....	3	.....	
Grimes Golden.....	3	1	3	.....	.....	.....	.....	Aphid on young growth.
Hastings	3	2	.....	3	.....	.....	.....	Aphid on young growth slight.
Hubbardston	3	1	.....	.....	3	.....	.....	

Hurlburt	3	3	10	5	.....	Aphis on young growth.
King	3	2	.....	2	.....	Aphis on suckers.
Longfield	2	1	.....	5	.....	Severe bloom inoculation on 2 trees.
McMahon	3	3	20	2	.....	
Maiden's Blush.....	2	1	2	.....	.....	Aphis present on young growth.
Milding	3	3	3	5	.....	Aphis present on young growth.
Missouri Pippin....	1	1	.....	3	.....	
Northwest Greening..	3	1	.....	1	.....	On one tree all suckers attacked and diseases had penetrated to root.
Northern Spy	12	5	5	.....	25	
Peter	3	3	3	1	.....	
Pewaukee	3	2	2	.....	5	Aphis on water-sprouts.
Red Astrachan	5	1	.....	5	.....	
Ribston Pippin	4	3	1	3	.....	The worst affected in the orchard.
Romenskoe	1	1	20	20	50	
Rome Beauty	2	1	3	.....	.....	1 tree, very bad attack of canker.
Roxbury Russet.....	3	2	4	2	.....	1 tree dying, girdled by canker.
Russians 182 and 270.	2	2	.....	12	.....	Aphis on suckers.
Salome	5	1	.....	.....	2	Aphis on young growth.
Scott's Winter	3	3	.....	3	.....	
Seek-no-further.....	3	3	.....	3	.....	
Shackleford	3	3	1	3	.....	
St. Lawrence	7	2	5	3	.....	This variety most severely affected in orchard. Infection through bloom, twigs, suckers, and water sprouts generally heavy. Aphis attack bad.
Tolman Sweet	8	7	20, 1 tree 75	45	50	Aphis bad on suckers.
Trenton	3	1	.....	.....	20	On this young tree planted in '07 the whole head was infected and had to be cut hard back during August to save it.
Vandevere	1	1	.....	50	.....	Very severe attack on young growth. Cankers on limbs and trunk at base of infected water-sprouts.
Wallbridge	6	3	.....	15	.....	

Apples and Pears.	Total number of trees.	Number infected.	Percentage of blossom infection.	Percentage of twig infection.	Percentage of water sprout infection.	Percentage of sucker infection.	Canker on main limbs or trunk.	REMARKS.
CRABS.								
Wagener	6	2	.....	.....	.....	5	.....	.....
Wealthy	7	2	4	.....	.....	5	.....	Aphis attack.
Winter St. Lawrence.	3	1	.....	3	.....	10	.....	Bad aphis attack on suckers.
Yellow Bellflower....	5	2	.....	.....	.....	5	.....	.....
Yellow Transparent..	6	1	.....	3	.....	.....	.....	.....
PEARS.								
General Grant	3	2	.....	.....	.....	25	.....	Very bad aphis attack on suckers.
Hyslop	2	2	.....	2	.....	5	.....	Very bad aphis attack on suckers.
Montreal Beauty	2	1	.....	.....	.....	5	.....	Very bad aphis attack on suckers.
Transcendent.....	3	3	.....	.....	.....	5	.....	Very bad aphis attack on suckers.
Whitney	2	2	5, 1 tree	2	.....	.....	.....	.....
PEARS.								
Bartlett	4	1	.....	10	.....	.....	limbs and trunk	Tree dying gradually.
Clapp's Favorite	8	2	.....	3, 1 tree	.....	.....	limbs and trunk	1 tree 5 years old killed off; canker on trunk.
Dempsey	2	1	2	.....	.....	.....	limbs.....	.....
Duchess	1	1	.....	3	.....	.....	trunk	.....
Doyenne Boussock....	2	1	.....	.....	.....	.....	main limbs.	.....
Easter Beurre	1	1	.....	.....	.....	.....	limbs and trunk	1 tree 12 years old practically dead from canker on limbs and trunk.
Flemish Beauty.....	24	11	.....	3, 1 tree	.....	5, 2 trees of 11 trees....	.....	.....
Lawson	1	1	.....	.....	.....	.....	main limbs	.....
Lincoln.....	2	1	.....	.....	.....	.....	main limbs.....	.....
Petite Marguerite....	1	1	.....	.....	.....	.....	limbs.....	.....
Ritson	2	2	.....	2, 1 tree	.....	.....	limbs and trunk	1 main limb killed off.
Seckel	1	1	.....	.....	.....	.....	trunk.....	.....
Tyson	2	1	2	.....	.....	.....	limbs	.....
Wilder.....	3	1	.....	.....	.....	.....	trunk	.....

APPLE AND PEAR TREE BLIGHT SURVEY, O.A.C. ORCHARD,
AUGUST, 1909.

VARIETIES OF TREES NOT ATTACKED BY BLIGHT, WITH NUMBER OF TREES OF EACH VARIETY.

APPLES.

Babbitt	2	McIntosh	3
Baldwin	2	McLean	3
Baxter	3	Minkler	1
Belle de Boskop	3	Northfield Beauty ...	1
Ben Davis	3	Ontario	3
Bethel	3	Peck's Pleasant	3
Bietigheimer	2	Primate	1
Blenheim	3	Rolfe	1
Bottle Greening.....	3	Shiawassie	3
Cinnamon	1	Stark	3
Cranberry	2	Tetofsky	3
Delaware Red	3	Utter	2
Golden Russet	3	Wellington	2
Gravenstein	5	Winter Banana	1
Hare Pipka	2	Wolfe River	3
Haas	3	Yellow Imperial	1
Lady	2		
Magog	3		

PEARS.

Anjou	16
Bartlett Seckel	1
Belle Lucrative	2
Beurre Hardy	2
Bessemianka	3
Bosc	1
Dr. Jules Guyot	1
Gifford	2
Goodale	2
Howell	2
Josephine de Malines	2
Kieffer	1
Lawrence	3
Louis Bonne	3
Manning's Elizabeth.	3
Novo Fulvie	1
President Drouard ..	1
Sheldon	3
Vermont Beauty	1

CRABS.

Martha	3
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The schedule shows the large number of varieties that are liable to infection. Even those varieties that showed no development of the disease are not necessarily exempt from its attack, but for some reason or other not known they have not so far shown signs of the disease. The diseased trees were scattered all over the orchard, so that all trees were equally liable to attack.

The varieties of apple in which the disease spread most rapidly when once it gained entrance are: First, Tolman Sweet; second, Romenskoe and the Russians Nos. 182 and 270, and third, the Colvert. In all these, especially the Romenskoe, large and very bad cankers developed in the bark of the trunk and main limbs at the base of water sprouts that were infected. Around some old cankers the bacillus had lived over winter and became active again in the spring. This appears to be rather a rare occurrence in other varieties. (See Figs. 23, 36, 37.)

Note that the disease in the apple trees is nearly all in the young growth, while in the pear trees it is confined largely to the main limbs and trunk.

Among the pear trees there was practically no spread of the disease from tree to tree. But the disease spread rapidly in those trees in which it had wintered over. All cases of new infection were those of our own inoculation experiments.

The Flemish Beauty, Clapp's Favourite and Bartlett were the varieties in which the disease spread most rapidly.

The schedule was filled in during August. During September and October no new cases were observed, but all cases of infection continued

to spread, and numerous cankers developed at the base of water-sprouts that had been inoculated by aphids.

2. MR. DUDLEY'S APPLE ORCHARD, WHITBY, JUNE, 1909.

This orchard contains about five hundred and fifty mature apple trees of eleven varieties. Mr. Dudley purchased it four years ago from its former owner, who had not found it a paying proposition. By cultivation, manuring and spraying, Mr. Dudley has obtained good returns. This year, however, after the blossoming season he noticed much of the young growth withering. At first he thought he had sprayed too heavily, but later, on finding that the withered twigs increased in number and size, he applied to Mr. Hare, District Representative of Agriculture, for information on the subject, and thence the matter came before our notice. We made an inspection of the orchard, and found it to be suffering from a very bad attack of twig blight, due to blossom infection.

The following schedule gives particulars:

Variety.	Number of Trees.	Number of trees attacked.	Percentage of twigs infected.	REMARKS.
Tolman Sweet ..	15	15 (100%)	80-90	All trees badly affected. Russets, Kings, Baldwins, Ontarios, all round lightly affected.
Baldwin.....	192	56 (29.1%)	20-30	
Greening	125	115 (92%)	20-50	
Spy	35	9 (25.7%)	5-20	
Spy grafts.....	40			No fruit on trees. Healthy foliage.
Duchess	24	15 (62.4%)	20-70	
King	18	4 (22.2%)	10-20	One very badly affected. Those not much diseased held but little fruit.
Ben Davis . . .	10			Not much fruit.
Snow	10			An odd twig here and there infected, very little fruit.
Russet	31	8 (25.5%)	5-15	An odd twig here and there infected, very little fruit.
Ontario.....	42	16 (38%)	10-20	Fair amount of fruit.

It will be seen from the above schedule that the Tolman Sweet variety was the worst attacked. The trees had blossomed heavily, and nearly every blossom on every tree had been destroyed by the blight, which passed into the twigs, killing them as it progressed. The Greenings came second in severity of attack and rapidity of spread, and the Baldwins third. It will be noticed that the trees not blighted had not blossomed.

3. An apple and pear orchard belonging to Mr. Bunker, of Pickering, proved, on examination, a splendid object lesson of what may

be done by the employment of proper means in combating disease in trees. This was an orchard of mature trees, and when purchased two years ago was suffering badly from blight canker and New York Apple Tree Canker on the main limbs and trunk of the trees. Early this spring, upon the advice and with the help of Mr. Hare, District Representative of Agriculture, who superintended the operations, all cankers



Fig. 45. Clapp's Favorite pear tree used in Experiment 5. The two twigs to the extreme right were the twigs inoculated. The disease passed down them to the crotch, from which it spread to all the other limbs and down the trunk.

were radically removed, and all blighted limbs and twigs were cut away, and three successive coats of thick white lead were given to the exposed areas. When we visited the orchard in June, it was in a state of thorough cultivation, every tree looked clean, healthy and vigorous, and not a sign of blight could be found. The owner stated that he kept

a sharp eye on the trees, and whenever he observed a case of blight he at once cut it out. We found numerous cases of blight in the neighbourhood of the orchard on apple, pear and hawthorn trees, so that it was simply due to the precautions taken that no blight was within the orchard. The owner's vigilance was amply rewarded.

4. Many of the pear trees in the orchard of Mr. Bartlett, Whitby, were badly blighted in the trunk and main limbs. When the

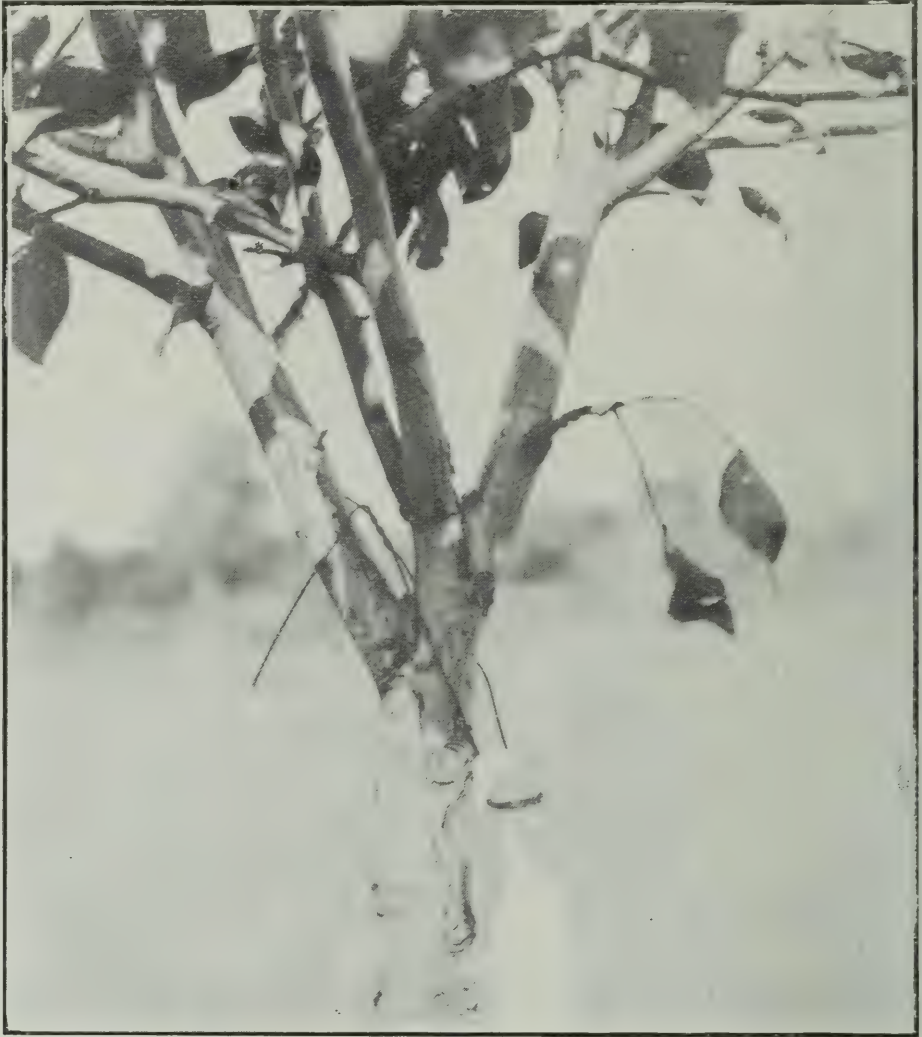


Fig. 46. Detail of same tree represented in Fig. 45, showing the blistered, cankered area outlined by the cracks in the bark down the trunk and up the limbs.

orchard was visited in June the disease was very active, and spreading rapidly within the trees affected. A few new infections from blossom inoculation were noticed. This orchard was under cultivation.

5. The pear orchard of Mr. Huggard, Whitby, was in sod, in which condition it had been for two years. Several trees killed by blight the

previous season were still standing, and numerous other trees had the disease, but not in a very active condition. The old cankered areas were plentiful in the trees, but the current season's development around these cankers was comparatively slight. A young apple orchard belonging to the same owner had considerable twig blight, due to blossom infection; in these cases the disease was very active.



Fig. 47. Flemish Beauty pear tree used in Experiment 5. The tip of the twig in centre was inoculated. The disease killed it and passed into the branch at its base. This it girdled, which resulted in the death of the branch.

6. In the orchard of Mr. Bunting, St. Catharines, we found an isolated row of pear trees, Flemish Beauty and Bartlett, that were very badly blighted in the trunk and main limbs. Two of them were dead, and the rest were so near it that Mr. Bunting had already decided to remove them. This row had formed a part of a pear orchard, all the

other trees of which had been killed by blight and removed from time to time.

7. Mr. W. McCalla, of St. Catharines, has a pear orchard containing Kieffer, Clapp's Favourite, Bartlett, Clairgeau, and some other varieties. He had cut out all the blight he could find last fall, but we found it to be still present and active on many of the trees, including the Kieffers. The orchard was under cultivation.



Fig. 48. Young apple tree used in Experiment 5. The branch in the centre is the one inoculated. The whole branch was killed. Note that the few leaves remaining on this branch are dead and shrivelled.

8. Mr. Stagg, St. Catharines, three years ago had a mature pear orchard of about two hundred trees. This season he had about thirteen of these left, all the rest having been removed after dying from the blight. The thirteen that remained were all badly blighted, and when

we were looking them over in July the disease was very active, the bark on the main limbs and trunk was blistering, and much thin, gummy liquid was exuding from the freshly cankered parts. Mr. Stagg intended to tear them all out this fall.

9. Mr. T. D. Jarvis, Grimsby, has three pear orchards, all in sod. One of these is composed of twelve-year-old Kieffers. Almost every tree in this orchard bore evidence of an attack by blight about three years ago. The ends of many branches had been killed back to a distance of from six to thirty inches, and in many cases the disease had continued to pass down the under side of the branch until a main limb or the trunk was reached; here usually it stopped, and there was but very little evidence of blight on the main limbs and trunk. The dead bark had shelled from many of these cankers, which had run down the under side of the branches, and the living bark was gradually healing over the wound.

The other two orchards contained several varieties of pears, Flemish Beauty, Clapp's Favourite, Bartlett, and others. These had a considerable amount of old blight canker in them, but not much that was very active, due probably to the fact that they had been in sod two or three years.

Mr. Jarvis has also a mature Greening apple orchard, and a mature Baldwin apple orchard. Both of these were badly infected with twig blight, due to blossom inoculation by bees and other flower-visiting insects, and later to the spread among the water-sprouts and young twigs by aphids. Nearly all the young growth on some trees was killed back by the blight.

Other orchards that we visited were those of Mr. E. D. Smith, of Winona, Mr. Tweddle, of Fruitlands, and Mr. Onslow, of Niagara-on-the-Lake, all of which we have referred to in the text.

In addition to these, we called in numerous other orchards while passing through the various districts visited. In these we found conditions similar to those already described. Wherever we went we could not fail to be impressed by the extensive ravages and heavy losses caused by the blight in the pear and apple orchards throughout the fruit districts generally.

We are thoroughly convinced, however, that with concerted action on the part of the fruit-growers, due care and adequate precautions as we have already suggested, the disease may be brought well under control, if not entirely eradicated, from our midst.

EXPERIMENTS.

EXPERIMENT I.—April 17th. (a) Inoculated two twigs on each of three Bartlett and three Flemish Beauty pear trees with broth cultures six days old from laboratory stock cultures of *B. amylovorus*. Inoculations were made by first puncturing or slightly tearing the bark near the end of the twig with a steel needle sterilized in an alcohol flame, then

with a sterile camel's-hair brush dipped into the broth culture, filling up the wound.

(b) Incisions made into bark of the main limbs of the same trees



Fig. 49. Blight cankered limb of Bartlett pear tree used in Experiment 2. The lower limit of the canker is shown by the irregular crack in the bark. The tissue used for culture experiments was taken from two inches within (a) and two inches without (b) the cankered area.

used in experiment (a). These wounds soaked with the broth culture by means of the camel's-hair brush.

(c) Two twigs on each of six young apple trees treated in the same way as the pear twigs in experiment (a).

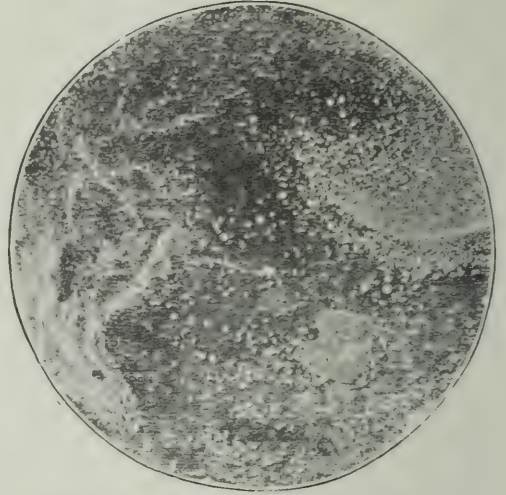


Fig. 50. Agar plate culture of *B. amylovorus*, obtained from the maceration of inner bark tissue taken from (b) outside the canker shown in Fig. 49. Every white dot is a colony of bacteria. The culture was pure. Incubated at 25° C. (Natural size.)

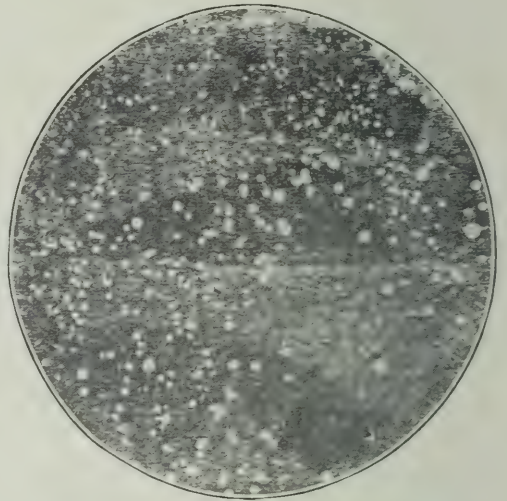


Fig. 51. Agar plate culture of *B. amylovorus* from a dilution of the mulch used for plate shown in Fig. 50. Incubated six days at 25° C. (Natural size.)

(d) Main limbs of the apple trees used in experiment (c) treated in same way as the limbs of pears in experiment (b).

Result.—Not one of these inoculations resulted in a development of the disease.

EXPERIMENT 2.—April 17th. Cut a cankered limb (see fig. 49) from a Bartlett pear tree. Washed the exterior with HgCl_2 , 1-1000, and with sterile knife obtained small portions of the inner bark from the cankered area and also from the discoloured area two inches from the crack marking the limits of the canker. This tissue was macerated in small quantities of sterile water, and three plate cultures of varying dilutions were made from each in beef-extract agar and gelatin; agar plates incubated at 25 deg. C. and the gelatin plates at 20 deg. C.

In twenty-four hours numerous minute colonies were seen on the agar plates made from the tissue taken from outside the cankered area, and in forty-eight hours similar colonies appeared in the gelatin plates made from the same material.

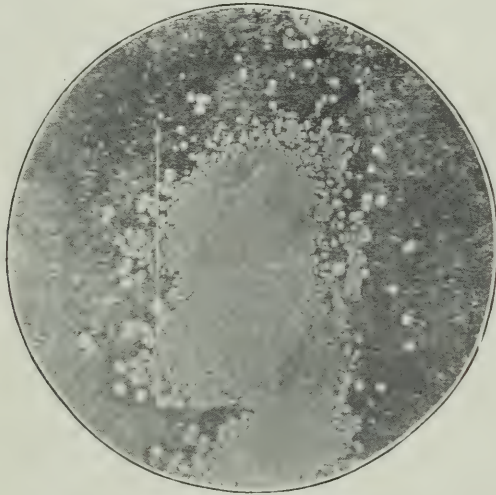


Fig. 52. Agar plate culture of *B. amylovorus* from inner bark of blighted apple twig. (Natural size.)

These all subsequently proved to be pure cultures of *B. amylovorus*. (Fig. 50.)

No colonies of *B. amylovorus* were obtained from the tissue taken from the cankered area. This tissue was dark brown, dry, tough, and evidently dead, while the tissue taken from outside the cankered area was moist and living, although it also was discoloured brown.

These experiments were subsequently duplicated after the limb had remained drying in the laboratory for six weeks, and similar results were obtained.

Conclusions.—The blight organisms live over winter, not in the dead cankered tissue, but in the living bark immediately surrounding the cankered area. This bark is usually discoloured purplish or dark brown. Many such cases were observed.

EXPERIMENT 3.—April 18th. Drew a pruning saw through the diseased bark of a Bartlett pear tree, and then with the saw made incisions into the bark of three pear trees and three apple trees, also cut off small branches from the same trees.

Result.—By the end of May, four of these cases developed the disease.

Conclusions.—When pruning, one should take care to cut well below cankered areas, and after cutting out a diseased limb should disinfect the cutting instrument.

EXPERIMENT 4.—May 6th. Isolated pure cultures of *B. amylovorus* in beef-extract agar, and gelatin from:

(a) Cankered pear limbs brought from the orchards of Mr. Onslow, Niagara-on-the-Lake.

June 10th. (b) Apple twigs from O. A. C. orchard.

(c) Young apple fruit, O. A. C. orchard.

(d) Exudate on diseased Bartlett pear, O. A. C.

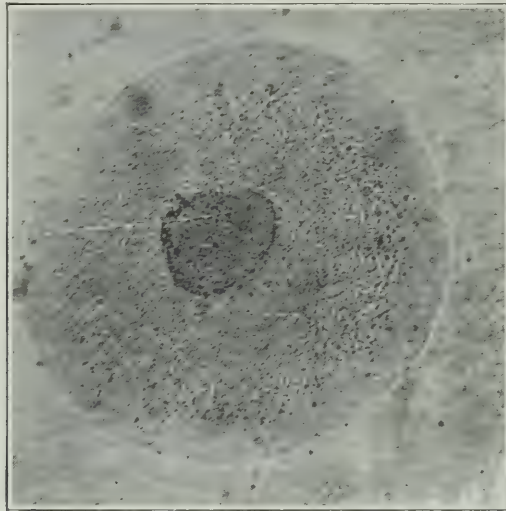


Fig. 53. Surface colony of *B. amylovorus* from agar plate culture shown in Fig. 51. Magnified 50 dia.

EXPERIMENT 5.—June 16th. (a) Inoculated one twig on each of twelve young healthy pear trees and on each of twelve young healthy apple trees with agar culture of *B. amylovorus* obtained from diseased pear tree limbs, Exp. 4 (a).

(b) Duplicated the above on the same trees with agar culture of *B. amylovorus* obtained from diseased apple tree twigs, Exp. 4 (b).

These inoculations were made by puncturing and slightly tearing the bark at the tip of the twig with a steel needle sterilized in an alcohol flame. The needle was then resterilized, and with it a small portion of the culture from the surface of the agar was transferred to the puncture.

In three days all twigs inoculated showed signs of the disease. The bark in the immediate neighbourhood of the puncture was brown and watery-looking. The young, unfolding, terminal bud leaves near the puncture were tinged a light reddish brown colour.

In three weeks the disease had visibly spread down some of the pear twigs from five to eight inches, and globules of amber-coloured gummy exudate were a marked feature on some of these. The disease progressed more slowly in the apple twigs. The leaves at the end of the twigs were light brown on the apple and dark brown or black on the pear, were gradually shrivelling, and the ends of the twigs were drooping as if dead.

By the end of August, in the case of a Clapp's Favourite pear, the disease had passed down the two twigs inoculated to the main branch which bore them, down this main branch to the crotch of the tree, a

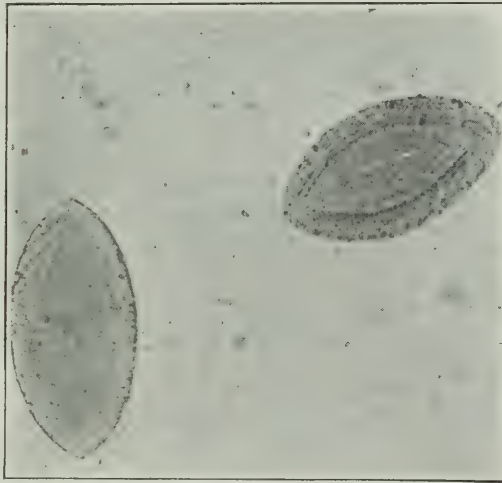


Fig. 54. Submerged colonies of *B. amylovorus* from plate shown in Fig. 51. Magnified 50 dia.

distance of four feet from the point of inoculation; at the crotch it entered the three other main limbs, up each of which it had progressed more than a foot, and also eight inches down the trunk. The bark of all these affected parts was cankered, cracked, and discoloured dark brown, and the characteristic gummy exudate was plentiful at various points. The leaves on the branch down which the disease had passed were black, shrivelled and dead, and the leaves all over the rest of the tree were beginning to look sickly, *i.e.*, turning dark brown, owing to the disease rapidly cankering the main limbs and trunk. By the end of the season the whole tree top and half of the trunk will be dead. (See Figs. 45, 46.)

This experiment shows the great rapidity with which the disease will spread when once it gains entrance to a susceptible pear tree. (See also Fig. 47.)

In none of the inoculated apple trees did the disease spread so rapidly as it did in any one of the pear trees. The apple tree which showed the greatest development was a Tolman Sweet. In this case, by the end of September the disease had passed a distance of three feet four inches down the twig and branch, killing the whole of the branch, but not seriously affecting the rest of the tree. (See Fig. 48.)

EXPERIMENT 6.—June. Obtained a blighted fruit spur from Yellow Transparent apple tree, O. A. C. orchard, in which the disease was active. Three blossoms had been killed, the disease passing down their pedicels to the spur, and then up two other pedicels, the fruit on which had developed to three-quarters of an inch in diameter when it became diseased. Diseased part of fruit brown, slimy, somewhat viscid when cut, surcharged with blight organisms. Cultures were made from

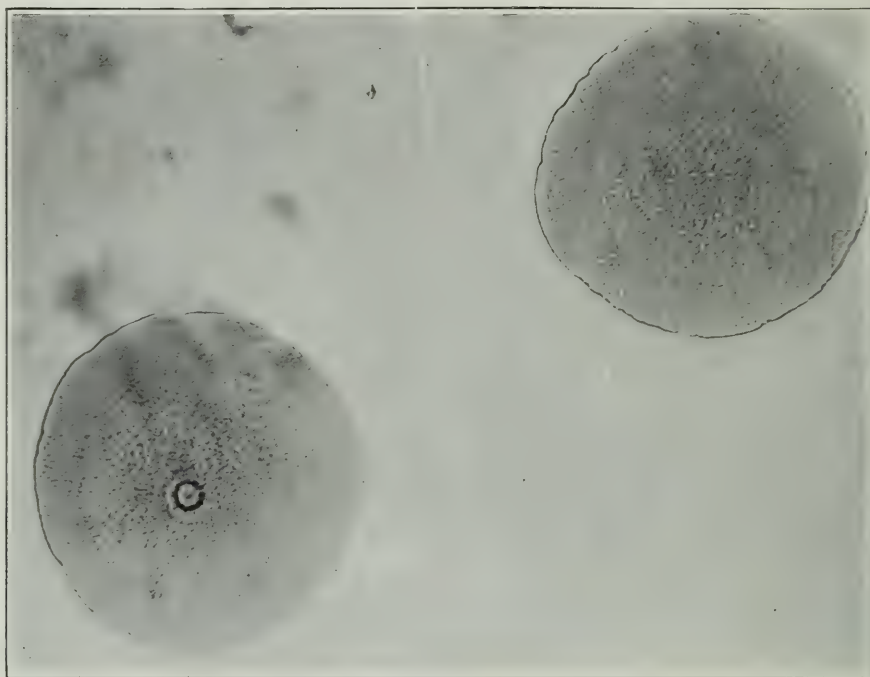


Fig. 55. Surface colonies of *B. amylovorus* on gelatin. Incubated three weeks at 20° C. Magnified 50 dia.

the fruit. The diseased tissue and pedicels were embedded in paraffin, and from each sample four-micron sections made, and stained with carbol fuchsin. These sections showed dense masses of organisms within the plant cells. In some cases some of the cell walls were broken down, in other cases numerous individual organisms were to be seen within the cells whose walls were not yet destroyed. (See Figs. 11, 12, 13, 14.)

EXPERIMENT 7.—June. Obtained fruit bark boring beetles, *Scolytus rugulosus*, in sterile test tubes from bark of diseased pear tree in O. A. C. orchard. Allowed one beetle to walk over surface of each of three

plates of beef extract agar and three plates of beef extract gelatin. In two days numerous colonies of *B. amylovorus* developed in their tracks. (See Fig. 39.)

EXPERIMENT 8.—July 4th. Obtained blighted twigs of apple trees, O. A. C. orchard, that were infested with aphids. Made cultures in beef agar and beef gelatin from the inner bark of the twigs and from the aphids. The heads of the aphids were macerated in a drop of sterile water and dilutions of this mixture were used in the plates. Pure cultures of *B. amylovorus* were obtained from the bark tissue, and mixed bacterial cultures obtained from the aphids. Many of these latter colonies were *B. amylovorus*.

EXPERIMENT 9.—July 6th. Obtained flies, *Musca domestica*, from surface of gummy exudate on diseased limb of pear tree on which the flies were feeding. Flies allowed to walk over beef agar plates. Numerous colonies of *B. amylovorus* developed in their tracks in two days.

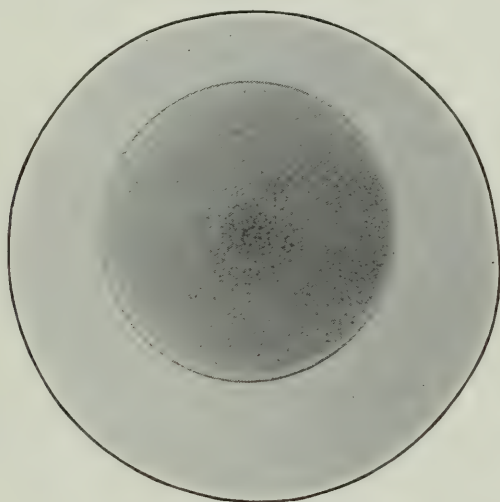


Fig. 56. Surface colony of *B. amylovorus* on gelatin. Incubated three weeks at 20° C. Magnified 50 dia.

EXPERIMENT 10.—July 10th. Brought six healthy young twigs of Flemish Beauty pear and six healthy young twigs of Yellow Transparent apple to the laboratory. Stood them with cut ends in flasks of tap water.

(a) Inoculated three of the apple twigs and three of the pear twigs with pure cultures of *B. amylovorus* grown on agar, by puncturing the bark at the tip of each twig with a sterile needle and transferring a little of the culture directly to puncture with the needle.

(b) Smeared on the outside of the bark of the other three apple twigs and pear twigs some of the culture.

Result.—In three days each of the three apple twigs in (a) showed signs of the disease. The terminal bud leaves were browned and the bark at the end of the twig also showed the organisms in numbers. The

pear twigs did not show such marked signs of the disease, but a blackening of the bark around the puncture was produced. No signs of the disease developed in (b) at any time.

EXPERIMENT II.—July 10th. Obtained nine young apples and nine young pears.

(a) Inoculated by puncture two apples and two pears with pure culture of *B. amylovorus* grown on agar.

(b) Inoculated two apples and two pears by puncture with gummy exudate from diseased apple taken from a blighted tree.

(c) Smeared agar culture of *B. amylovorus* over surface of two apples and two pears.

(d) Smeared exudate from diseased apple over surface of two pears.



Fig. 57. Submerged colony of *B. amylovorus* in gelatin. Incubated three weeks at 20° C. Magnified 50 diameters.

Kept one apple and one pear as controls.

These fruits were placed in sterile deep Petri dishes, to which a little sterile water was added, and incubated at 25°C.

In three days the tissue around all the punctured inoculations was softened and turning brown. In three weeks the skin over about one-third of the surface of each of these was wrinkled, somewhat sunken, dark brown, the tissue beneath soft, pulpy, slimy, and teeming with the organisms. In several instances drops of amber-coloured exudate were on the surface.

None of the fruits on which the culture or exudate were smeared developed the disease.

The controls remained sound. (See Figs. 15 and 16.)

BACILLUS AMYLOVORUS.

MORPHOLOGY AND CULTURAL CHARACTERS.

Source.—Two cultures were isolated, one from a diseased apple twig and one from exudate on a diseased pear tree, O. A. C. orchard, June 10th. These cultures were used to inoculate young pear and apple trees in Exp. 5. The two strains were again isolated from the inoculated trees in which the disease had rapidly spread and were carried simultaneously through the various culture media with like results.

I. MORPHOLOGY.

Veg. cells from diseased tissue, agar colonies 3 days at 25°C., gel. colonies 5 days at 20°C., and bouillon cultures 3 days at 25°C., short rods, rounded ends; mostly single, sometimes in twos. Chains of from 4 to 12 segments are a characteristic on Loeffler's blood serum. Limits of size, 1 to 1.8 x .5 to .9 microns.

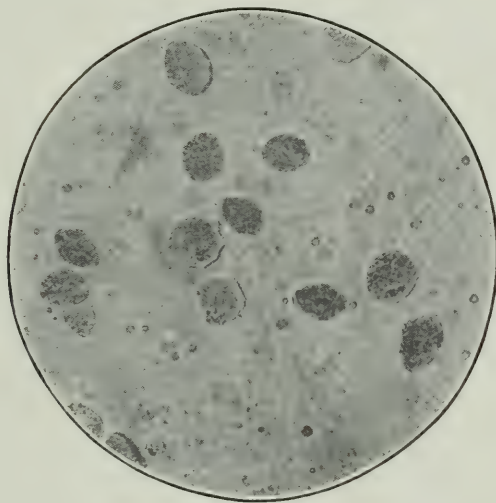


Fig. 58. Group of small surface colonies on gelatin. Incubated three weeks at 20° C. Magnified 50 dia.

Spores.—None observed at any time in any medium.

Flagella.—1 to 3 at or near one pole. Stained by Moore's modification of Loeffler's flagella stain. Figs. 3, 4.

Staining Reactions.—Watery and alcoholic solutions of gentian violet, carbol fuchsin, and methylene blue, good; Gram's, negative; Ziehl-Neelson, negative.

II. CULTURAL FEATURES.

Agar Stroke.—Growth moderate, filiform, slightly raised, glistening, young cultures smooth, older cultures tendency to contour, slightly gray, semi-opaque, butyrous.

Potato.—Growth moderate, slowly spreading, flat or slightly raised, glistening, smooth, colourless, butyrous.

Loeffler's Blood Serum.—Colourless growth similar to that on agar, no liquefaction.

Agar Stab.—Filiform, uniform growth.

Gelatin Stab.—Filiform, uniform growth; slight tendency to liquefaction on surface after 20 days.

Nutrient Broth.—Moderate clouding, uniform; no pellicle; no ring; scant, finely granular sediment after 10 days at 25°C. No odour.

Milk.—Soft coagulum after 4 days at 25°C. Very slight digestion after 20 days at 25°C.

Litmus Milk.—Turned white in 4 days, slightly pink in 6 days, white again in 12 days, upper layers blue again in 18 days.

Gelatin Colonies.—Growth rather slow, round, slightly raised, entire, gray; young cultures finely granular, older ones grumose when seen through microscope low power; no liquefaction after fifteen days. (Figs. 56, 57, 58.)

Agar Colonies.—Growth rapid at the start at 25°C., but maximum development obtained in 5 or 6 days; usually small, not more than 2 to 3 millimetres; round, smooth, flat or slightly raised, entire or undulate, young cultures finely granular, older ones coarsely granular to grumose. (Figs. 53, 54.)

Silicate Jelly (Fermi's solution).—Moderate growth on surface, thin, grayish; medium not stained.

Starch Jelly.—Growth moderate, diastasic action present on third day at 25°C., the upper layers being liquefied; after 6 days 30 per cent

Cohn's Solution.—No growth. NOTE.—This medium tested +43° to phenolphthalein, Fuller's scale. A portion was reduced to +10° by addition of NaOH. This caused a precipitate of magnesium hydroxide, which was filtered out. No growth occurred in this solution.

Uschinsky's Solution.—Growth copious, not viscid.

Sodium Chloride in Bouillon.—½%, 1%, 1½%, 2%, 2½%, 3% of sodium chloride added to bouillon medium 3° acid did not inhibit growth at 25° C. The higher percentages of salt checked the growth on first 2 days, but after 4 days all media were densely clouded and had a granular precipitate.

Nitrates in Nitrate Broth.—None reduced; no ammonia, no nitrates, no free nitrogen produced.

Indol.—None formed in Dunham's solution.

Toleration of Acids.—Bouillon 4° acid to phenolphthalein used as foundation stock. To this was added HCl, increasing acidity to +8°, +10°, +12°, +14°, +16°. In 2 days at 25° C. uniform clouding in +8° and +10°; no perceptible growth in +12°, +14°, +16°. In 4 days

uniform clouding in each tube, but the density of growth decreased as the acidity increased.

Toleration of NaOH.—Same foundation stock used as for the acid test. NaOH added to increase alkalinity to -2° , -4° , -6° , -8° , -10° . Growth occurred in media up to -6° .

Optimum Reaction.—Neutral.

Vitality on Culture Media.—Seldom living in any medium after 5 months in the dark at room temperature.

Temperature Relations.—Freshly inoculated bouillon cultures exposed 10 min. at 50° C. were killed.

Similar cultures exposed 10 min. at 45° C. were not killed.

Bouillon cultures incubated at 37° C. did not develop.

Bouillon cultures placed in refrigerator showed no development in 5 days.

Agar plates freshly seeded were placed in ice and salt freezing mixture, temperature of which varied from 0° C. to -10° C. Two plates were removed after each of the following periods of time, and incubated at 25° C.—30 min., 1 hr., 2 hrs., 4 hrs., 8 hrs., 20 hrs. Growth occurred in every case. 50% killed in the 20 hrs., freezing. Best temperature for growth, 23° C. to 25° C.

Resistance to Drying.—Cover glass smears of broth cultures dried in the dark, at room temperature, for 5 days, gave good growth in bouillon.

Similar smears dried in bright sunlight for 30 minutes gave growth in bouillon.

Similar smears exposed to bright sunlight 30 minutes and kept dry in laboratory for 6 days gave no growth in bouillon.

Sunlight.—Thinly sown agar plates exposed to bright sunlight for 15 minutes showed after incubation about 5 per cent. killed. Similar plates exposed under same conditions for 30 minutes showed about 15 per cent. killed.

Fermentation tubes containing peptone water and:

2% Dextrose gave no gas, but a strong, clouded growth throughout.

2% Saccharose gave no gas, but a light, clouded growth throughout.

2% Lactose gave no gas, but a light, clouded growth throughout.

2% Maltose gave no gas, but a strong, clouded growth throughout.

2% Glycerin gave no gas, but a light, clouded growth throughout.

2% Mannit gave no gas, but a strong, clouded growth throughout.

A very slight increase of acidity resulted from growth after 5 days.

Pathogenesis.—Pathogenic to following genera of Rosaceæ: *Pyrus*, *Cratægus* and *Amelanchier*.

SUMMARY OF CONCLUSIONS.

1. Bacterial blight of apple, pear and quince trees causes more loss to the pome fruit grower in Ontario than any other agent of loss.

2. *B. amylovorus*, the cause of the disease, lives in the cells of the bark and fruit, the contents of which it destroys, causing withering of the twigs, canker of the limbs and trunk, and rot of the fruit.

3. The disease is spread from branch to branch, from tree to tree, and from district to district—(A) by insects carrying the germ on the outside of their body: (1) bees, wasps and other flower visiting insects inoculating the blossom; (2) aphids and other sap sucking insects inoculating twigs; (3) fruit bark boring beetles and other borers inoculating branches and trunks; (B) saws, knives and other workmen's tools when pruning operations are in progress.

4. All blighted parts of trees should be cut away as soon as noticed where possible. Systematic cutting out of blighted parts should be practised during late fall. When cutting away an affected part, care should be taken to cut well below or around the blighted area. The instrument used should be disinfected each time after use. Care should be taken not to rub a diseased part against a healthy part when removing it. All diseased wood should be burned as soon as cut away.

5. Aphids and borers, active carriers of the disease, should be kept in check.

Seeing that this year the Government appointed a number of orchard survey men to report on the conditions found in the orchards throughout the Province, we would strongly recommend that for their work next season these surveyors be trained to recognize the blight in its various forms of attack, twig and canker on the apple, pear and quince trees, and be able to give the necessary advice to those immediately concerned as to the proper methods to be adopted in its control and eradication.

In conclusion, we wish to thank, for kind assistance given from time to time during this investigation, Prof. S. F. Edwards of this department, Dr. Bethune, Messrs. Jarvis and Caesar of the Biological department, and Mr. Cooper, the orchard foreman at the College. We wish to thank also all the farmers whose orchards we visited, who were only too willing to answer all questions and to show us around their orchards, even during the busy season when they could ill afford the time necessary.

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[DECEMBER, 1909

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE.

Lime-Sulphur Wash.

BY H. L. FULMER AND LAWSON CÆSAR.

INTRODUCTION.

The Lime-sulphur wash has been used in Ontario for about twelve years, and, although it is a disagreeable material to work with, it has proven to be so useful that it has steadily gained in popularity, until to-day it is the standard remedy for the San José scale. The wash is also useful in destroying other scale insects, and, furthermore, it is recognized as a valuable and efficient fungicide. In fact it is without doubt one of the best all-round spraying materials at the disposal of the fruit grower at the present time.

This valuable spraying mixture was first used by the California fruit growers, who accidentally found that the Lime-sulphur sheep dip of Australia would destroy the San José scale. When the scale spread to the Eastern part of the Continent, the California remedy, or Lime-sulphur wash, quickly followed it. At first it was used entirely to control the ravages of the San José scale, but it was soon found to destroy the Oyster Shell Bark Louse and other forms of scale insects, and, quite accidentally, it was discovered that it controlled the Peach Leaf Curl. This suggested that the Lime-sulphur wash had fungicidal value. Up to this time the wash had always been used on trees in the winter or early spring, and was of a strength only suitable for use on the wood in the dormant condition. If, however, the mixture was to be useful as a fungicide for more than the Peach Leaf Curl, it must be sprayed on the trees during the growing season.

The commercial Lime-sulphur solutions next appeared on the market. They are concentrated solutions, which do not crystallize like the home-made article, consequently, they can be kept any length of time and diluted as required for spraying purposes. These commercial washes were at first viewed with suspicion, but it was soon found that when properly diluted they gave excellent results both on dormant wood and on tender foliage. The foliage of the peach tree is an exception, as it was found that even with what appeared extreme dilution the commercial washes still burned the leaf. In the endeavour to get a fungicide to control the Brown Rot of the peach tree, the self-boiled Lime-sulphur wash was introduced and has given excellent results. This latter material and the diluted commercial solutions are now being successfully used as Summer sprays without russetting the fruit or otherwise injuring it or the foliage, as sometimes happens with the Bordeaux Mixture.

With regard to the composition of the Lime-sulphur wash, it has always been evident that there were wide variations. Salt was a constituent of the original sheep dip and was retained, with the idea that it added to the caustic qualities, and particularly to the adhesive nature of the wash. In practical experience, however, the salt seems to have been of little benefit, and is, therefore, omitted in all the formulæ now given. The formulæ have varied from time to time and in different districts; in some instances very excessive quantities of lime have been used, but the nature of the compounds found did not vary with the different proportions of the ingredients. In all cases the mixture contained the essential sulphides of Calcium and some thiosulphates and sulphites, with traces of sulphates. The amount of these latter compounds was dependent upon the length of time the mixture was boiled and the vigour with which the boiling was prosecuted. Indeed, it is quite probable that the rate of boiling has been responsible for greater variations in the strength of the home-made wash than any other one factor, for, while 45 minutes to one hour's vigorous boiling has been proven to be sufficient, a longer period of *slow* boiling will frequently leave some of the sulphur uncombined or in the lower forms of the sulphides, and, hence, give an inferior wash.

The self-boiled washes in which caustic soda and sal soda were used to aid the action, which were advocated at one time, gave fairly satisfactory washes, but so much depended on having a fresh quick-slaking lime that the results obtained were not uniform and they are seldom made now. The self-boiled washes now advocated contain much smaller quantities of combined lime and sulphur and are purposely arranged to make weak washes for Summer spraying.

The commercial Lime-sulphur solutions which have been placed on the market during the last few years have some decided advantages over

the home-made article. They are clear solutions containing a larger proportion of the sulphur in the form of the higher lime sulphides, and, because of the absence of large quantities of free lime, they do not crystallize. Consequently, they can be diluted to the required strength and applied at once, doing away with the rather disagreeable work of preparing the wash. However, it is very doubtful if these commercial articles will ever replace the home-made material for Winter spraying, unless they can be sold for less money.

The most recent advance in the preparation of the Lime-sulphur wash is the introduction of a method for making the home-made concentrated solution. The method is simple and consists essentially of boiling together lime and sulphur in the proportion of 1 : 2, allowing the residue to settle and drawing off the clear supernatant solution. A wash can easily be prepared in this way, that is 8 or 9 times as strong as that made from the old formula for home-boiled mixtures, and, as it does not crystallize, it can be made during the slack time in the Winter and stored ready for dilution when required.

The difficulty in handling both the commercial solution and the home-made concentrates is to know how much they should be diluted before applying. The solution prepared from the old formula, lime, 20 lbs., sulphur 15 lbs., water 40 gals. (Imperial), may be taken as a fair standard of strength for spraying dormant wood. But, so far as we know, no analyses of these washes have ever been published. To secure this data we collected and analyzed a large number of samples, and while, as was to be expected, there is a wide variation in the strength of the different samples, an average should give a fair standard. Knowing, then, the strength or density of the wash required it is a comparatively simple matter, by use of the hydrometer, to dilute any concentrated solution to the desired strength, either for a winter or summer spray. Thus a fruit grower may make his own concentrated solution or purchase the commercial article and dilute to a definite basis and apply a wash of a uniform strength, or, he may dilute to the strength desired for the different kinds of fruits he wishes to spray.

R. HARCOURT,

Prof. of Chemistry

PART I.

CHEMICAL STUDY.

BY H. L. FULMER.

NEED OF A STUDY OF THE COMPOSITION OF LIME-SULPHUR WASHES. The Lime-sulphur wash has now become a popular spray, and is gradually becoming more and more a general spray for orchard control work. But owing to the real lack of definite information and knowledge concerning the composition, preparation and application of this wash, farmers and fruit growers have many questions to ask regarding it which we are often unable to answer, except in a general way. This lack on our part has been doubly emphasized to us since the recent introduction of what are known as the Commercial Lime-sulphur solutions. Farmers were using and knew the value of the home-made wash, but this new thing was untried and was rightly regarded with doubt. They came to us with questions as to the value and genuineness of this new material, but we had no figures of our own nor of others on the approximate composition of either the home-made wash or the commercial brands. Therefore we could not make any statement as to the similarity of the two washes or, if similar, as to their comparative strength.

The need above indicated, then, led us to gather some data during the past year on the composition of the Lime-sulphur washes, both home-made and commercial. To get fair figures on these, our samples were obtained from as large a number of orchardists as possible and from that district which is recognized as the leading fruit-producing one of the Province. We endeavoured also, in collecting our samples of the home-made wash, to draw them from all parts of the District as far as possible so that their analyses would present figures which would represent average composition of these as they are being made and applied.

Besides the analysis of the samples of washes collected, we have also made a study of some other points in connection with the wash, and the results of and discussion on this work will be included along with those on the former.

COLLECTION OF SAMPLES. Our samples of washes were all collected in the Niagara fruit district, with the exception of a few representing the commercial brands. This district was visited in April (19-23), and then again in May (13-14), and the territory covered extends from Niagara-on-the-Lake and Queenston on the Niagara River front up along Lake Ontario as far as Fruitland. Thus nearly all the fruit belt below the escarpement is represented in the samples which we obtained. In all, twenty-eight samples of the washes were taken, and of these

twenty-four were of the home-made variety, and the remainder represented commercial brands. Considering, in addition, the fact that six of the samples of home-made wash were taken from steam boiling plants that were supplying a large number of orchardists in their vicinity with the spray, namely, two at St. Catharines, and one each at St. Davids, Homer, Grimsby and Winona, it will be seen that we have secured samples which will give a thoroughly fair representation of the nature and composition of the home-made Lime-sulphur washes being used over the greater part of the Niagara fruit belt for Winter spraying.

When collecting the samples notes were kept regarding the methods of manufacture. This includes data as to whether steam or direct heat were used for boiling; kind and quality of *lime* and *sulphur* used; length of boiling period, etc., and these, where useful, will be introduced into the general discussion.

METHODS OF ANALYSIS.

The various determinations which we have made in our study of the composition of the Lime-sulphur washes include the following:

- (a) Specific gravity (commercial washes),
- (b) Sulphur in solution.
 - (1) Total sulphur,
 - (2) Sulphide sulphur,
 - (3) Iodine sulphur,
 - (4) Sulphur in other forms.
- (c) Lime in solution.

Solutions Required:

- (a) *Ammoniacal Zinc Chloride*: Made according to Sutton (Volumetric analysis, p. 323, 7th Ed.).
- (b) *Bromine Solution*. Made by saturating a 20 per cent. solution of potassium bromide with bromine.
- (c) *Barium Chloride*: A 20 per cent. solution.
- (d) *Methyl Orange indicator*.
- (e) *Nickel Sulphate indicator*.
- (f) *Decinormal Iodine*.
- (g) *Starch solution*.

SULPHUR.

Preparation of Sample:

(a) **HOMEMADE WASHES**: The sample was thoroughly mixed. In cases where orange crystals had formed the whole was first heated to 70° C. in a water bath until the crystals had dissolved. One hundred c.c. were then taken (when the wash was not at full dilution a proportionately less quantity was taken) and passed through an asbestos filter with the aid of the pump. This removed all of the residue or "mud."

The residue was washed with cold water until free of sulphides as indicated by mixing a drop of filtrate with a drop of NiSO_4 indicator on a white plate. Filtrate and washings were then combined and made up to a volume of 500 c.c.

(b) **COMMERCIAL WASHES:** A ten c.c. portion of the well mixed wash was measured out. In the case of those brands from which the "mud" is not removed by the manufacturer, filtering of the sample was carried on just as with the homemade washes. The whole was then made up to a volume of 500 c.c.

Determination:

(a) **TOTAL SULPHUR:** 50 c.c. of the bromine solution were added to a 500 c.c. beaker containing about 200 c.c. of water, and then, while stirring, 25 c.c. of the sample were slowly run in from a pipette. Excess of bromine was then removed by evaporation, 10 c.c. of HCl added, and the SO_4 precipitated and estimated in the usual way. $\text{BaSO}_4 \times .13732 = \text{S}$.

(b) **SULPHIDE SULPHUR:** The sulphides in 25 c.c. of the sample were precipitated with Ammoniacal Zinc Chloride, added in slight excess as indicated by Nickel Sulphate as an external indicator. Ammonia was then removed by heating on the steam bath. The precipitated sulphides were next washed thoroughly by decantation and on the filter paper, dissolved in 25 c.c. of KOH (1:1), oxidized on the steam bath with 75 c.c. of hydrogen peroxide for 30 min., slightly acidified with HCl and the resulting SO_4 precipitated with BaCl_2 and estimated in the usual way.

(c) **IODINE SULPHUR:** These forms of sulphur were determined in the filtrate and washings from the precipitated sulphides. The liquid was made acid with HCl , using Methyl Orange as indicator, then alkaline with solid Sodium bicarbonate, a little starch solution added, and then the reducing sulphur compounds titrated with decinormal iodine solution. The reducing sulphur was figured as thiosulphate * sulphur.

(d) **SULPHUR IN OTHER FORMS:** Obtained by subtracting the sum of sulphide and iodine sulphur from the total sulphur.

LIME.

The total lime in solution was obtained from the same sample as that prepared for the determination of the sulphur. A 25 c.c. aliquot was oxidized with bromine in the same way as for total sulphur, the excess of bromine driven off by evaporation, 10 c.c. of HCl introduced, and the lime precipitated with solid ammonium oxalate and ammonia, and estimated in the usual manner.

*This would not give an absolutely correct value for reducing sulphur on account of the presence of the sulphite, but it has been found that this latter substance is present in such small quantity in lime-sulphur solution as to be negligible.

VALUATION OF A LIME-SULPHUR WASH.

Before an idea of the efficiency of a lime-sulphur wash can be gained from a table showing its composition, a knowledge regarding the value of the various compounds mentioned as occurring in it must be had. Value relates to the power which is possessed for killing insects or fungi, or preventing their attack, depredations or growth.

The value of the different compounds is in the main only comparative, and in practice is either high, medium, low or nil. Thus of two compounds A and B, both intended to be used for the same purpose, A may be stated to be more valuable than B for that purpose. Both may accomplish their work, A more quickly or thoroughly than B. Both may fail in their work, B more completely than A. A may accomplish its work, B may not, and yet it cannot be stated definitely just how valuable either one of them is when either be thought of apart from the other. All we can say is that the value of A is higher than that of B.

The above outlines the position we are in when we come to treat of the value of the various compounds which occur in lime-sulphur washes. We know that when the wash is well made and thoroughly applied it forms a very effectual treatment for San José scale and many other small insect pests, and also for many fungus diseases; but we do not know the definite value of any of the compounds of which it is composed. The comparative value only of these substances is known. Thus, the most valuable of the constituents are the sulphur compounds; and of these the most valuable are the sulphides. Then, in order of merit, come the "thiosulphates, sulphites (both reported, combined, as Iodine sulphur in solution) and sulphates (reported as Sulphur in solution in other forms)". Outside of the sulphur compounds we have the "lime in solution," and the residue or "mud." These materials are practically inert and useless. It must not be overlooked, however, that the former is very important indirectly, in that the existence of the sulphur compounds depend on it; and that the residue is also useful in that it acts as a marker during the spraying operation, and that it also is claimed to increase the length of time that the wash is active on the tree, and, further, that it improves the sticking qualities of the wash.

Since the sulphur compounds are the most valuable constituents of the wash, we must use them as a basis for valuation. Sulphide sulphur is the most valuable sulphur compound present, therefore in placing value on two washes, we value that one the higher which has the greater quantity of sulphide sulphur per unit volume. This method does not take in the factor of economy. A wash may be so strong as to be applied at a great waste. The matter of *correct* strength is a problem by itself and depends on—purpose of application, time of spraying, degree of infestation, etc. In the present discussion we wish only to discuss the washes themselves, as the practical application of them has received no attention at our hands.

HOME-MADE WASHES.

Following is a table showing the composition of the twenty-four samples of home-made washes which we collected in the Niagara fruit district. Data regarding formulæ, kinds of lime and sulphur used, and methods of boiling are also included.

It will be seen that quite a variety of formulæ are used in making the home-made wash. The lime varies in amount from 16 pounds to 24 pounds, and the sulphur from 15 pounds to 19 pounds. The most popular formula is 20 pounds of lime and 15 pounds of sulphur.

No. 1 Sulphur, sometimes called A, which is Flour of Sulphur 1st quality, is used by all; the kind of lime used varies with the locality.

One hour is the favourite boiling period, but some boil as little as 40 to 45 minutes, and others as much as $1\frac{1}{4}$ to $1\frac{1}{2}$ hours, and even up to 2—3 hours. The common way of boiling is by means of steam. This is because steam is much more convenient to use than direct heat.

The strength of the washes varies markedly. The total sulphur runs from 8.51 pounds to 17.40 pounds per 40 gallons, and the sulphide sulphur is present in amounts varying from 6.29 pounds to 13.28 pounds per 40 gallons. The average of all the washes gives 13.89 pounds of total sulphur, and 10.41 pounds of sulphide sulphur per 40 gallons. As a rule about 75 per cent. of the total sulphur is in the form of the sulphide. This is shown in the last column. Therefore, when the quantity of either one of these forms is known, the quantity of the other can be approximately calculated. A high total sulphur content indicates a correspondingly high sulphide sulphur content.

TABLE I.—SHOWING THE COMPOSITION OF HOME-MADE WASHES AS MADE BY DIFFERENT ORCHARDISTS.

Sample No.	Quantity of material		Kind of lime.	Kind of sulphur.	Length of boiling period.	Method of boiling.	Total sulphur in solution, lbs. per 40 gals.	Sulphide sulphur in solution, lbs. per 40 gals.	Iodine sulphur in solution, lbs. per 40 gals.	Sulphur in other forms in solution, lb. per 40 gal.	Total lime in solution, lbs. per 40 gals.	Ratio of total lime to total sulphur.	Per ct. of total sulphur in form of sulphide.
	Lime, lbs.	Sulphur, lbs.											
126	20	19	Pt. Colborne	No.1	1 hour	pan steam	17.31	13.00	4.20	0.11	10.72	1 : 1.61	75.1
127	22	18	"	"	"	"	9.58	7.31	2.21	0.06	5.97	1 : 1.60	76.3
128	16	16	"	"	1-1½ hrs	pan	13.58	9.61	3.74	0.23	8.69	1 : 1.56	70.8
129	20	16 17	"	"	2-3 hrs	"	8.51	6.29	2.05	0.17	5.76	1 : 1.48	73.9
130	20	16	"	"	40 min	"	14.45	10.85	3.23	0.37	8.84	1 : 1.63	75.1
132	20	16	"	"	1 hour	steam	11.55	8.46	2.72	0.37	6.86	1 : 1.68	73.2
133	20	16	"	"	"	"	13.30	9.08	2.46	1.76	7.09	1 : 1.87	68.3
134	20	15	Beachville	"	"	"	10.57	8.00	2.36	0.21	6.69	1 : 1.58	75.7
135	24	15	"	"	½-1 hour	"	15.90	12.22	3.05	0.63	10.66	1 : 1.49	76.8
137	20	16	"	"	1 hour	"	14.30	11.48	2.59	0.23	9.40	1 : 1.52	80.3
138	20	15	Pt. Colborne	"	"	pot	17.11	13.06	2.77	1.28	9.05	1 : 1.89	76.3
139	20	18	"	"	1½ hours	"	14.12	10.54	3.33	0.25	8.52	1 : 1.65	74.7
140	20	15	"	"	1 hour	steam	14.86	11.09	3.49	0.28	8.55	1 : 1.74	74.6
142	20	15	"	"	45 min	"	14.13	9.97	3.23	0.93	9.14	1 : 1.55	70.6
143	20	17	Hamilton	No.1	1 hour	"	17.40	13.28	3.92	0.20	10.09	1 : 1.72	76.3
144	22	17½	"	"	"	"	16.46	12.68	3.69	0.09	9.96	1 : 1.65	77.0
145	22	"	"	"	"	"	14.04	10.63	3.23	0.18	8.53	1 : 1.65	75.7
146	22	"	"	"	"	"	10.49	7.82	2.56	0.11	7.41	1 : 1.41	74.6
152	22	18	Pt. Colborne	"	till green color develops	pot	17.40	13.14	3.90	0.36	10.25	1 : 1.69	75.5
149	22½	17½	Hamilton	"	45 min	steam	14.88	11.14	3.49	0.25	8.73	1 : 1.70	74.8
150	22	16	"	"	1 hour	"	15.95	11.48	4.05	0.42	10.12	1 : 1.58	71.9
147	18	15	"	A	50 min	"	8.86	6.80	1.96	0.10	5.49	1 : 1.61	76.7
153a	18	15	"	"	"	"	12.99	9.92	2.99	0.08	7.97	1 : 1.63	76.4
153b	22	18	"	"	"	"	15.64	11.91	3.59	0.14	9.35	1 : 1.67	76.1

The Iodine Sulphur makes up quite a large proportion of the total sulphur. This material is made up of thiosulphate and a small quantity of sulphite, and although not nearly so valuable as the sulphide sulphur, yet it imparts considerable efficiency to the wash.

The sulphur in other forms is mostly sulphate. It is of no value in the wash, but, except in three or four cases, it occurs in such small quantity as to be negligible. The main point to be remembered in connection with this substance is that it is present as the result of the breaking down of the more valuable sulphide and thiosulphate sulphur during boiling. Prolonged or over-boiling increases its amount, therefore the desirability of controlling the boiling process.

Total lime in solution is not important, except that it is an indication as to the amount of sulphur in solution. The greater the amount of lime, the greater the amount of sulphur. This is shown quite clearly in the column, "Ratio of total lime to total sulphur," where it is seen that the proportional amounts of lime and sulphur are fairly constant. Thatcher states * that lime and sulphur dissolve in the proportion of 1 part lime to 1.94 part sulphur; and that after allowing for the lime in solution (in the wash) as calcium hydroxide, the ratio of lime to sulphur is always about 1 : 2.24. The amount of lime in solution in these washes varies from 5.76 pounds to 10.72 pounds per 40 gallons.

COMMERCIAL WASHES.

Most of the commercial washes are made up of the clear liquid which is obtained when a wash is allowed to settle. The liquid in the case of these washes, however, is much more concentrated than is the liquid which would be obtained from the ordinary home-made wash as usually made. It is the high concentration of these washes which makes them so feasible. By a dilution of 8 or 10 times, or more, with water, a wash can be obtained of as great strength as the average home-made wash, with the elimination of the trouble of boiling, and other inconveniences experienced in making the wash at home.

It will be noticed in the next table that the commercial washes contain the same constituents as do the home-made ones. The difference lies in the quantity of these present; the concentration is much greater; and a greater proportion of the total sulphur is in the sulphide form and less in the thiosulphate and sulphate form. The ratio between lime and sulphur is also somewhat greater.

Omitting No. 13, which contains a large amount of residue, or "mud," it will be seen that the strength of these washes corresponds very closely to the specific gravity reading, *i.e.*, the greater the amount of sulphur in solution, the greater is the specific gravity. For this reason the manufacturers of these washes use the hydrometer for controlling the strength of their product, knowing that when the solution attains a certain density it will closely approximate a certain strength.

* Jour. Amer. Chem. Society ; Vol. 30, p. 64 and p. 65.

TABLE II.—SHOWING THE COMPOSITION OF DIFFERENT BRANDS OF COMMERCIAL LIME-SULPHUR WASHES.

Sample No.	Brand and Source.	Specific Gravity of Clear Liquid.	Total Sulphur in Solution, lbs. per gallon.	Sulphide Sulphur in Solution, lbs. per gallon.	Iodine Sulphur in Solution, lbs. per gallon.	Other forms of Sulphur in Solution, lbs. per gallon.	Total Lime in Solution, lbs. per gallon.	Ratio of total Lime to total Sulphur.	Per cent. of total Sulphur in Sulphide form.	One gallon will make.*	Remarks.
131	Grasselli, from Cold Storage, St. Catharines ...	1.2927	3.245	3.018	0.192	0.034	1.352	1 : 2.40	93.0	11.6 gals. of spray	No sediment.
136	Niagara, from T. H. Griffiths, St. Catharines	1.2927	2.799	2.586	0.192	0.021	1.292	1 : 2.17	92.3	9.94	Large amount of sediment.
148	Vanco, from C. P. Carpenter & Son, Winona.....	1.2946	3.176	2.991	0.167	0.018	1.525	1 : 2.08	94.1	11.49	No sediment.
151	Vanco, from T. D. Jarvis, Grimsby	1.2325	2.371	2.123	0.231	0.017	1.068	1 : 2.22	89.5	8.15	"
154	Vanco, from Horticultural Department, O.A.C.....	1.3230	3.566	3.405	0.154	0.007	1.597	1 : 2.23	94.8	13.1	"
156	Rex, from Rex Company, Rochester, N.Y.....	1.2946	3.268	2.990	0.192	0.086	1.310	1 : 2.49	91.5	11.48	"
157	Sherwin - Williams, from manufacturers.....	1.3000	3.225	3.019	0.179	0.027	1.430	1 : 2.25	93.6	11.6	"

* This column is figured on sulphide sulphur content, taking as a standard the sulphide content of the home-made wash, 10.41 lbs. per 40 gallons, which is the average for the 24 home-made washes analyzed.

Most makers aim at a density of about 1.2946 (33° Bé). When the mud is left in the wash, however, as in No. 13, the amount of combined sulphur per unit volume is greatly decreased. Consequently, this factor is only applicable in the case of the clear solution. In this connection, it might be stated that the hydrometer could be used to great advantage in controlling the strength of the home-made wash. The instrument is cheap, and very easily manipulated, and its use would tend to reduce the making of the wash to a system, and lead up to the making of a more uniform product, and to a greater intelligence in its application.

HOME-MADE AND COMMERCIAL WASHES COMPARED.

There is no doubt but that the commercial lime-sulphur solutions are nearly identical in every way with the home-made solutions in so far as composition is concerned; and, therefore, it is quite reasonable to expect that when applied in the same strength as the home-made wash they will be just as efficient. There are some differences in the two washes, however, which might affect the comparison, viz., the thiosulphate would be present in greater quantity in the home-made wash, the home-made wash is applied hot, and the commercial brand does not contain the residue or "mud." It is hard to judge just what would be the extent of difference caused by these factors. Thiosulphate is a more or less active constituent in the spray, and therefore the home-made wash would be somewhat more valuable for that reason. By spraying hot it is likely that the spray will spread much better, and a very important factor in determining the results of spraying is the thoroughness with which the surface of a tree is covered. The presence of the "mud" adds to the life of the wash, causes it to adhere better, and in itself has an insecticidal value; and, further, it gives a means of controlling the spraying by virtue of the whitewashing effect which it has on the trees. The absence of residue in commercial washes, which do not contain it, can, however, be controlled to a great extent by the addition of lime to them.

Most of the manufacturers of commercial washes recommend their product to be diluted one to eleven. From the next to last column in Table II., it will be seen that only one wash can be diluted to that extent and still give a spray with a sulphide content equal to the average home-made wash. The most satisfactory way for an orchardist to dilute these products, in order to get the proper strength, would be to control the dilution by means of an hydrometer. A commercial Lime-sulphur solution, without any sediment, will, when diluted so that it will contain .260 pounds of sulphide sulphur per gallon—the average of the home-made wash—have a specific gravity of about 1.028. Therefore, if in diluting, water be added until this density be reached, the amount of dilution which the sample can sustain will be determined.

RESIDUE OR "MUD."

When the home-made wash is allowed to stand quietly for a short time till it has had time to settle, a large quantity of material gathers at the bottom of the container. The amount and nature of this residue will vary. Under ordinary conditions it will consist largely of the excess of lime which has been used in making the wash, together with a certain amount of the impurities of that material. But in case of the use of large quantities of sulphur in the formula or in underboiled washes, due to either too short a time or too slow boiling, a great part of it may consist of free sulphur. Some decomposition products, such as calcium sulphate and calcium sulphite, may also be present.

To gain some idea as to the nature of this "mud" in a well-made wash, we analyzed a sample of it. The following are the figures:

Lime (CaO)	54.513 per cent.
Sulphur (S)	.793 per cent.
Carbon dioxide, etc. (by difference)	44.694 per cent.
100.000 per cent.	

Besides the Carbon dioxide, the 44.694 per cent. will consist of varying small quantities of iron, magnesium, etc., depending upon the nature of the lime which has been used.

It will be seen from the above figures that the residue from this particular wash will possess very little, if any, more virtue than ordinary lime when applied alone. Where much free sulphur is present, then the residue would be more valuable, since sulphur is quite an active fungicide. Outside of what has been said elsewhere, then, it will be noted that the liquid part of the wash is really the active part, the residue being merely an adjunct.

CRYSTALS.

When the wash cools it slowly deposits beautiful orange red needle-shaped crystals. These will be found mixed throughout the residue. They probably consist of a combination of one of the sulphides of calcium with lime. According to some authorities,* they have the following formula: $3\text{CaO} \cdot \text{CaS}_4 \cdot 12\text{H}_2\text{O}$. The formation of these crystals goes on at the expense of the strength of the wash, and this is one reason why it is advisable to spray while hot, or at least before cooling has continued long enough, usually about 12 to 24 hours, to allow crystallization to take place. Free lime is essential to their deposition, and thus it is that we do not find them to any extent in commercial solutions, where the only free lime present is that which may be held in solution in the liquid. It is also said† that air is necessary to their

* Watts' Dictionary of Chemistry, Vol I., p. 667.

† Bull. No. 92, Penn. Experiment Station.

formation, and that if air be excluded, as by completely filling the container with the wash and then sealing, or by covering the exposed surface with oil, no crystallization will take place.

These crystals will dissolve readily in water heated to 60° or 70° C., leaving a white residue. Thus, if a wash which has cooled to crystallization be heated up again before spraying, most of the sulphur deposited will again be brought into solution.

A sample of these crystals was analyzed by us, and the following table shows their approximate composition:

Total Sulphur (S) in soluble part	18.622	per cent.
Total Lime (CaO) in soluble part	16.390	"
Total Sulphur (S) in insoluble part	0.000	"
Total Lime (CaO) in insoluble part	25.341	"
	59.353	"

or,

Total Sulphur	18.622	per cent.
Total Lime	41.731	"
Water of crystallization	39.647	"
	100.000	

According to the formula $3\text{CaO} \cdot \text{CaS}_4 \cdot 12\text{H}_2\text{O}$, the composition would be as follows:

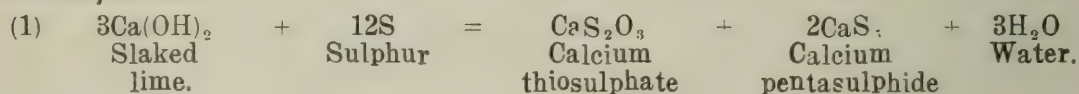
Sulphur (S)	23.19	per cent.
Lime (CaO)	40.58	"
Water of crystallization	39.10	"
	102.87	"
Subtracting	2.87	" of oxygen.
	100.00	

The main thing to be inferred from the above composition is that any considerable amount of crystallization will remove from solution a great deal of sulphur, and sulphur in its most valuable form.

CHEMISTRY OF THE SULPHUR COMPOUNDS IN LIME-SULPHUR WASH.

The following are the reactions which the sulphur undergoes during the preparation of the wash and after the wash is on the tree* :—

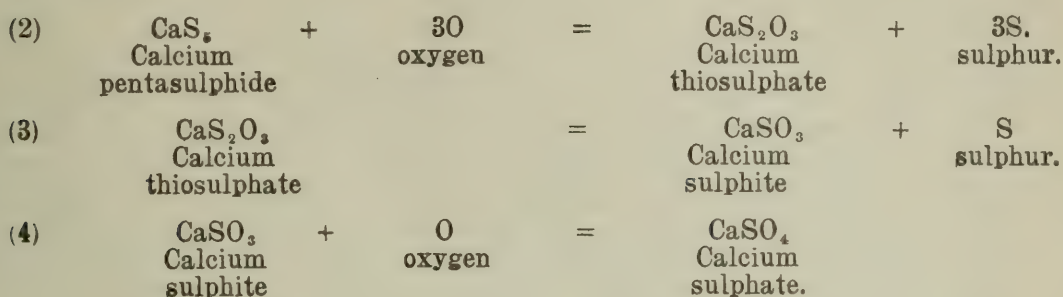
Manufacture :



This reaction illustrates the main chemical change which goes on during the boiling of the wash, showing the formation of the pentasul-

* Haywood Journal Amer. Chemical Soc., Vol. 27, pp. 244-355. Thatcher Journal Amer. Chemical Soc., Vol. 30, pp. 63-68.

phide and the thiosulphate. The following secondary reactions will also proceed:



showing the further formation of thiosulphate, and also the formation of sulphite and sulphate. The free sulphur liberated in (2) and (3) again takes part in reaction (1). Thus a sort of cycle is maintained, during which a gradual increase in the amount of thiosulphate, sulphite and sulphate takes place. When all the original sulphur added has taken part in reaction (1), then the valuable pentasulphide begins to suffer rapidly, and thus it is that undue prolonged boiling when making the wash is objectionable.

On the Tree:

The reactions given in (2), (3) and (4) represent what takes place after the wash is on the tree. Thus, it will be seen, the final products of the wash are free sulphur and calcium sulphate (gypsum).

The residue will also be present, and will now consist largely of calcium carbonate.

THEORIES REGARDING THE ACTION OF THE WASH.

Nothing definite is known regarding the action of the Lime-sulphur wash which causes it to be so effective in destroying the San José scale and the various other insects, and fungi; but some knowledge of the properties and actions of some of the constituents help us to formulate some theories as to the probable cause of its effectiveness.

(1) CAUSTIC ACTION. All who have ever had anything to do with the manufacture or application of the wash know how very disagreeable it is to handle, on account of its very corrosive or caustic action. The exposed part of the person must be protected from the wash, as well as horses, harness, and other perishable parts of the spraying outfit. It is reasonable to expect then that if the tender body of an insect or the mycelium or spore of a fungus, be exposed to this sort of dosage, destruction or at least a very considerable check in growth and increase will be effected. To this action of the wash a great deal of its effect must be attributed, and it is to the sulphide that this caustic property of the wash is due. The sulphides are aided to a considerable degree in their work by the free lime which is present, by the somewhat appreciable caustic action of this material also, but more by reason of the fact that lime will tend to loosen the protecting scale of the scale insects

from the bark, and expose the unprotected body of the inmate to the sulphide. This action of lime is the secret of its value in combating the Oyster Shell bark louse.

(2) FREE SULPHUR. Sulphur has long been known to be valuable for combating fungus and insect pests. Years ago it was used with great success for controlling the powdery mildew of the grape in France, where that pest was the great scourge of the wine industry. For this purpose the sulphur was merely dusted over the leaves. According to reactions 2 to 3 under "Chemistry of the Sulphur Compounds," sulphur is deposited from the Lime-sulphur wash. This occurs through the decomposition of the sulphides and the thiosulphates, and this sulphur will have a marked advantage over sulphur that would be dusted on in the original form in that it is in a very much more finely divided condition, and, further, that the surface of the tree would be more perfectly covered with it.

Just how this fine sulphur acts is not known. It has been suggested* by some that its action is due to the fact that it becomes changed to sulphur dioxide through the heat of the sun and the oxygen of the air, and that it is this compound or the sulphurous acid into which it would readily change in the presence of the moisture of the air, which effects the benefits. Haywood,† however, partly disproves this, for he found in his experiments that total and free sulphur on the tree did not decrease in amount even after the end of four weeks, which could not possibly happen if the sulphur became oxidized, for under these conditions a great deal of it would volatilize. As Haywood states, however, it is not disproven that the sulphur dioxide does not form in quantity appreciable enough to be of great value, but only that this compound is not accountable for the major action of the wash.

(3) SULPHITES. These compounds are quite active as antiseptics, and would therefore by virtue of this property act as fungicides or insecticides, to a greater or less degree. During the decomposition of the wash Calcium sulphite is formed in quite large quantity, the thiosulphate finally all changing to this compound. Such a theory as this would explain why the action of the wash extends over such a long period, for it takes several weeks for the decomposition into sulphite to become complete. The sulphite in its turn becomes changed to the more stable but inactive Calcium sulphate; still, as long as thiosulphate is present, its continued decomposition will present considerable quantity of the sulphite.

From what has gone before, then, it would appear that the caustic action of the sulphides, aided by the free lime, and free sulphur and sulphite from the decomposition of the sulphides and the thiosulphates, impart to the Lime-sulphur washes their efficacy for insect and fungus control work. A drenching rain right after spraying would greatly lessen or perhaps destroy the effects of a wash, for the sulphides and

* Journal Amer. Chemical Society, Vol. 27, p. 254.

† Ibid p. 255.

thiosulphates, the mother substances of the sulphites, and free sulphur, are readily soluble, and therefore would soon be washed off the tree. And frequent showers throughout the life of the wash would also be quite harmful, because of the constant removal of the thiosulphate. A period free from heavy showers during the spraying season would be ideal for obtaining the maximum effect of Lime-sulphur washes.

MANUFACTURE OF HOME-MADE WASHES.

A great variety of methods are in vogue for the manufacture of the home-made wash. The appliances used, especially for boiling with direct heat, are often very ingenious, and a visit to a fruit district where spraying is quite general shows the length to which orchardists will go in order to get the spray when they have once wakened up to the fact that spraying must be practised if orchards are to be maintained on a paying basis.

Judging from the great variety of practices followed and opinions held in regard to the making of the wash, there seems to be a great lack of definite knowledge as to the principles underlying the manufacture of the mixture. Some of these differences relate to the kind and quantity of materials to be used, others to the method of boiling and the length of time necessary for complete boiling, and others to various minor details in the process of making and applying.

In view of the above, we have carried out a few experiments on the manufacture of the wash, in order to obtain some figures bearing on these points. The nature and discussion of these experiments follow:

EXPERIMENT I.—DIFFERENT KINDS OF LIME FOR MAKING LIME-SULPHUR WASH.

In this experiment we aimed to find what influence limes of various degrees of purity would have upon the strength of the wash. Four limes were tested which in composition are representative of all lines that will be found on the market in Ontario. They include the pure lime of Beachville and the dolomite of Guelph, and also the limes of Port Colborne and Caledon, which latter are depressed in purity on account of the presence of such substances as iron, aluminum, silica, etc.

The following figures will show the purity of these limes:

Beachville.....	99.4	per cent. CaO
Port Colborne	86.4	" "
Caledon	91.6	" "
Guelph (dolomite limestone)	{ 48.8	" "
	{ 37.2	" MgO }

Washes were made from each of these lines, and analyzed. Following is a table showing their composition. Formula: Lime 20 pounds, sulphur 15 pounds, water 40 gallons. Method of Boiling: By steam.

Lime.	Time boiled. min.	Sulphur as sulphides. lbs.	Sulphur as thiosulphates and sulphites. lbs.	Amount of sulphur in solution. lbs.
Beachville	60	12.19	1.76	13.95
Port Colborne.....	60	12.77	1.83	14.60
Caledon	60	12.89	1.76	14.65
Guelph	60	13.10	1.65	14.75

Here we have the rather unexpected phenomenon of obtaining the strongest wash with the weakest lime. There is a difference of .8 pounds of total sulphur in solution between Beachville and Guelph lime in favour of the Guelph; and further, Beachville, the purest lime, has given the weakest wash all through. All these washes are good, however, and none of them but would give satisfactory results in spraying, leaving out of consideration the amount and composition of the residue.

An interesting point brought out in this experiment is the fact that twenty pounds of lime in the case of those of a high purity gave a great excess of CaO over that required to bring fifteen pounds of sulphur into solution. Twenty pounds of Guelph lime will furnish 9.77 pounds of CaO, while the same amount of Beachville lime will contain 19.88 pounds of CaO; still, Guelph lime furnishes enough of the oxide of Calcium to bring into solution a maximum amount of the 15 pounds of sulphur. Arguing from this, 20 pounds of Beachville lime must furnish at least 10.11 pounds of CaO in excess of that required. In other words, 20 pounds of Beachville lime are sufficient to dissolve over 30 pounds of sulphur.

From the relation which exists between lime and sulphur in solution, in Lime-sulphur wash, 1 part of CaO will combine with 1.94 parts of S. It appears then that 15 pounds of sulphur actually require about 7.73 pounds of CaO to bring it into solution. From this even 20 pounds of *Guelph* lime, with its 48.8 per cent. purity, will furnish 2.04 pounds of CaO in excess of the necessary amount.

In view of the foregoing facts, it can be safely argued that the formula 20-15 will in all cases furnish sufficient lime for making a satisfactory wash; and further, that judging from the table of analysis, dolomite limestone, such as is found in the Guelph formation, produces lime suitable for the manufacture of the Lime-sulphur wash.

EXPERIMENT II.—TO COMPARE FLOUR OF SULPHUR, AND FLOWERS OF
SULPHUR FOR MAKING LIME-SULPHUR WASH.

Lime used: Beachville.

Formula: Same as in Expt. I.

Method of boiling: By steam.

Kind of Sulphur.	Time boiled. min.	Sulphur as sulphide. lbs.	Sulphur as thiosulphate and sulphite. lbs.	Amount of sulphur in solution. lbs.
Flowers of Sulphur.....	20	9.67	1.06	10.73
“ “ “	40	11.33	1.83	13.16
“ “ “	60	11.62	1.83	13.45
Flour of Sulphur.....	20	10.94	1.48	12.42
“ “ “	40	12.37	1.62	13.99
“ “ “	60	12.19	1.76	13.95

The above results show that Flour of Sulphur combines more rapidly and more completely with lime than do the Flowers of Sulphur. The difference between the two, however, is not so great but that the matter of choice between the two forms would rest rather on cost than on form. From Table I. it is seen that Flour of Sulphur (called No. 1 or A) is used altogether in the Niagara district, due to the fact that it is cheaper, and also that it is found to be just as satisfactory.

The completeness and rapidity with which sulphur will enter into combination with lime depends on its fineness. Haywood cites an experiment which he performed with a sample of coarse, dark coloured brimstone sulphur in making lime-sulphur wash. He found that no inducement would cause this sulphur to combine with lime rapidly, or anything near completely, until it was powdered finely, after which it was almost as satisfactory as Flour or Flowers of Sulphur.

Given several varieties of sulphur, then, the finest and purest one should be chosen as the most suitable for making the Lime-sulphur Wash.

EXPERIMENT III.—LENGTH OF TIME NECESSARY TO BOIL IN ORDER TO OBTAIN THE MAXIMUM COMBINATION OF LIME AND SULPHUR.

Formula: Same as in Expt. I.

Method of boiling: By steam.

Lime.	Time boiled. min.	Sulphur as sulphide. lbs.	Sulphur as thiosulphate and sulphite. lbs.	Amount of sulphur in solution. lbs.
Beachville.....	20	10.94	1.48	12.42
“.....	40	12.37	1.62	13.99
“.....	60	12.19	1.76	13.95
Pt. Colborne.....	20	11.04	1.27	12.31
“.....	40	12.77	1.54	14.31
“.....	60	12.77	1.83	14.60
Caledon.....	20	11.29	1.48	12.77
“.....	40	11.97	1.69	13.66
“.....	60	12.89	1.76	14.65
Guelph.....	20	9.41	1.06	10.47
“.....	40	11.40	1.41	12.81
“.....	60	13.10	1.65	14.75

Maximum combination has taken place practically in every case at the expiration of one hour; and in case of the Beachville and Pt. Colborne limes we have indeed a maximum sulphide content after only forty minutes of boiling.

From the figures shown, it is clear that one hour's boiling is sufficient for preparing the wash, regardless of the kind of lime used; and further, that some limes unite more readily with sulphur than do others. If the boiling period be pushed past that time necessary for maximum combination, the cost of manufacture increases; and further, the effectiveness of the wash decreases, because of the breaking down of the valuable sulphur compounds into less valuable ones: viz., sulphides into thiosulphates and sulphites, and also sulphites into sulphates. In fact, prolonged boiling will actually reduce the amount of total sulphur in combination, as is shown by the Beachville lime in the above table. This last would happen more readily when direct heat is used for boiling, as in the pot or pan method.

It must be borne in mind, however, that the *rate of boiling* will determine the length of time necessary for maximum combination. In the above experiment *vigorous boiling* was maintained throughout the boiling period. Although the strength of the wash will vary in ratio to the amount of lime and sulphur used, no quantity of materials will give a wash of maximum strength if the boiling is not properly done. *Weak, slow boiling* on account of a small fire or low steam pressure will never give a good wash even after prolonged boiling. If Table I. be

examined, some interesting points will be noticed regarding the strength of the various washes. Although the formulæ vary considerably, yet we do not find that we always get the greater quantity of sulphur in solution where we have the larger quantities of materials used (compare Nos. 127 and 128 or 132 and 133, Table I.), nor the same amount where we have the same quantities of materials (compare Nos. 129, 130 and 132, or 140-146, Table I.). There is not a formula there indicated but would give a splendid wash if the boiling be properly done, yet there are some of them that are remarkably low in combined sulphur and show a great waste in uncombined sulphur. All such have been underboiled because of a slow fire or low steam pressure. Sulphur left uncombined will probably be no more effective than sulphur that is merely mixed with water and then applied.

Boil vigorously and then any of the average formulæ will give a good wash, without the boiling period being longer than from forty-five minutes to one hour.

EXPERIMENT IV.—THE EFFECT OF INCREASING THE PROPORTION OF SULPHUR TO LIME.

Lime used: Beachville.

Water: Forty gallons.

Method of boiling: By steam.

Amount of lime. lbs.	Amount of sulphur. lbs.	Time of boiling. min.	Sulphur as sulphides. lbs.	Sulphur as thiosulphate. lbs.	Amount of sulphur in solution. lbs.
20	15	60	12.89	1.76	14.65
20	20	60	16.00	2.54	18.54
20	20	120	16.18	2.68	18.86

The main effect observable in the above table, caused by increasing the proportion of sulphur to lime, is that the amount of total sulphur in solution is increased. This is what we would expect to happen so long as the lime is present in sufficient quantity as to be in excess. Since, as stated elsewhere, 1 pound of lime (CaO) is a sufficient quantity to dissolve 2 pounds of sulphur, then 20 pounds of Beachville lime (99.4% CaO) will be sufficient to cause about 40 pounds of sulphur to go into solution.

The amount of sulphur which goes into solution, however, does not bear a direct ratio to the amount which is used. According to the figures, 15 pounds of sulphur with 20 pounds of lime furnish 14.65 pounds

of combined sulphur; and 20 pounds of sulphur with 20 pounds of lime furnish 18.54 pounds of combined sulphur. The increase in the amount of sulphur used is equal to 33 per cent., whereas the increase in combined sulphur is only 27 per cent. Longer boiling up to 2 hours increases the amount to 29 per cent., but even then it is 4 per cent. below. There would be a slight increase in the waste of sulphur, then, where the larger proportion is used, but the increase in the amount of wash obtained would amount to 10.8 gallons, the value of which would easily cover the cost of the 5 pounds extra sulphur used, the only additional expense. Figuring sulphur at \$1.50 per cwt., the extra wash prepared would cost .69c. per gallon; whereas the cost of preparing one gallon of home-made wash averages about 1c. Therefore increasing the amount of sulphur in our formulæ up to a certain limit appreciably decreases the cost of production, and more so is this true when we allow that the increased amount of wash is produced without entailing any additional cost in time, labor and fuel.

The main point to be noticed where the proportion of sulphur to lime is increased is that the amount of sulphur in solution is correspondingly increased, although not in direct proportion. This fact is taken advantage of in the manufacture of the factory-made solutions, which are from 8 to 10 times or more stronger than the average home-boiled wash. The same fact can be taken advantage of also for making home-made concentrates, a matter which will be dealt with later on.

EXPERIMENT V.—TO COMPARE STEAM AND DIRECT HEAT METHODS OF BOILING.

Lime used: Beachville.

Formula: Same as Experiment I.

Method of boiling.	Time boiled. min.	Sulphur as sulphide. lbs.	Sulphur as thiosulphate and sulphite. lbs.	Amount of sulphur in solution. lbs.
Direct Heat.....	20	10.94	1.48	12.42
“ “	40	12.37	1.62	13.99
“ “	60	12.19	1.76	13.95
Steam Heat.....	20	10.94	1.13	12.07
“ “	40	11.86	1.69	13.55
“ “	60	12.52	1.69	14.21

From the above results it is seen that direct heat induces a more rapid combination of the lime and sulphur than does the steam heat, but gives a wash of slightly lower value. The difference shown, however, does not give any decided choice of method. Considering the greater

convenience of boiling by steam, it is perhaps the most desirable way to prepare the wash; still there are many small orchardists who have not the facilities at hand to boil by steam, in which case its preparation by direct heat may be conveniently and cheaply employed.

A point which has been mentioned before and which can here again be emphasized is that the results of boiling and the strength of the wash depend more largely on the *vigour* with which the boiling is carried on than on any other one factor, other conditions being equal. *Slow boiling*, no matter what the source of heat be, will always give weak, unsatisfactory washes.

In view of the more rapid combination of the lime and sulphur, and also of the tendency to decomposition after a certain point is reached, it is recommended that the boiling period be confined within the limits of 45 to 50 minutes when direct heat is used.

EXPERIMENT VI.—ON THE DEVELOPMENT OF A GREEN COLOUR IN THE WASH DURING BOILING.

It is thought by some who make and use the Lime-sulphur wash that the development of a green colour is a good indication as to when boiling is complete. We found this colour formation to be due largely to the presence of iron in the lime, or to that derived from the vessel in which the boiling is carried on, or from the pipes conveying the steam. The fact remains, at least, that in the absence of iron or some other similar metal, such as copper, lead, nickel, etc., this colour does not develop, even after prolonged periods of boiling. Hence the colour change cannot be used as an indicator. The length of time it takes for the colour to develop depends upon the amount of iron, etc., which is present. With some limes with which we have worked the colour appeared about the time that the maximum amount of sulphur is in combination, viz., one hour, and therefore in such cases serves as an indicator; but with other limes it did not develop until long after that period; while with others it developed within 20 minutes, at which time only about three-quarters of the sulphur is in combination. Plainly, then, the colour change is an indication of the completeness of boiling only in cases where those limes are used which contain a certain amount of iron or other like metal.

Port Colborne lime, which is used extensively in the St. Catharines district, always produces the green colour, and at the end of about one hour; but Beachville and Hamilton limes do not produce it.

EXPERIMENT VII.—ON THE DEPRECIATION OF THE WASH IF ALLOWED TO COOL.

When the Lime-sulphur wash is allowed to stand for some time a large quantity of orange red crystals form in the residue at the bottom

of the container. This happens at the end of 12 to 24 hours. These crystals are made up largely of sulphide sulphur, and their formation results in a lowering of the strength of the solution. They cannot readily be sprayed, as they tend to clog the nozzle, and even if they could be applied to the tree they would not be very effective. By heating the spray up to 60° to 70° C. (140° to 158° Fah.) these crystals can be quite readily dissolved, however, and their value regained to a great extent.

The following figures show the difference in composition of two washes, one of which has been allowed to cool for 24 hours and then heated up again, the other conditions being maintained alike:—

Lime used: Beachville.

Formula: Same as used in Experiment I.

Method of boiling: By steam.

Treatment.	Sulphur as sulphide.	Sulphur as thiosulphate and sulphite.	Amount of sulphur in solution.
Boiled 60' and analyzed at once	12.19	1.76	13.95
Boiled 60', cooled 24 hrs., brought to a boil and analyzed at once	11.91	2.01	13.92

These figures show that the wash becomes slightly less valuable when allowed to cool before being applied, the sulphide and total sulphur having both decreased in amount. The difference in these two washes is so small, nevertheless, as to be negligible, and if at any time a batch of wash be allowed to cool and crystallize before it is sprayed, it should not by any means be discarded. If it be heated up and boiled for a few minutes it will be almost as valuable as before.

HOME-MADE CONCENTRATES.

One of the greatest inconveniences connected with the use of the home-made wash is the amount of time and bother which is required for boiling it; and this at a time when, as a rule, labour could be used much more profitably in some other direction. For this reason the commercial brands of Lime-sulphur appeal to some orchardists, although the spray in this form is a little more expensive. This is especially true now since Lime-sulphur has begun to take the place of Bordeaux mixture as a summer spray, for at this season of the year it seems almost out of place to boil, and it is much more congenial and a great deal handier to dilute from a stock solution. In view of the fact that the results obtained from these purchased materials are as satisfactory as those produced by the home-boiled stuff, it is quite safe to predict that many orchardists will soon come to use them altogether. When these materials were first introduced fruit growers were a little dubious as to their

value, and were rather conservative in their use of them, but in the light of experimental work that has been carried on with them, both by practical men and Experiment Station workers here in Canada and also in the United States, their usefulness and similarity in composition and source with the home boiled article are now apparent.

These factory boiled Lime-sulphur solutions, for obvious reasons, could not compete successfully with home-made washes if the latter could be stored for any length of time without deteriorating considerably in quality. The home-made wash could be made in quantity during the less busy times of the winter, and be ready for use as soon as the spraying season opened up in the spring. But its crystallizing property and, what is more important, the fact that it would require an immense amount of storage space, puts such a procedure out of the question.

Recently, however, it has been demonstrated that it is quite possible to make a home-made concentrated Lime-sulphur solution that will compare very favourably with the concentrated commercial solutions.* If this can be done, then the main difficulty in the way of preparing the season's wash during the winter, viz., the lack of storage facilities, will be largely overcome. The principle on which the concentrate is made does away with the excessive crystallizing tendency, *i.e.*, as elsewhere stated the use of a large quantity of sulphur in proportion to the lime, so that very little uncombined or free lime is left at the end of the boiling period.

If the maximum quantity of sulphur to lime be used, *i.e.*, with a lime like Beachville 99.4 per cent. pure, 40 pounds of sulphur, to 20 pounds of lime (or 2 to 1), and the quantity of water used be kept within minimum limits, a very strong Lime-sulphur solution can be manufactured, and a solution which on cooling will not deposit crystals. This is the basis on which a home-made concentrate can be made, suitable for storage.

A formula for preparing the concentrate and directions of procedure are given by Professor Stewart,† of Pennsylvania Experiment Station, which is very suitable for making about 40 gallons of mixture at a time, an amount which will give from 32 to 35 gallons of clear liquid concentrate similar to the clear commercial brands.

His formula and directions are as follows:‡

50 lbs. best stone lime (not over 5% impurities).

100 lbs. sulphur (flour or flowers).

40 to 45 gallons of water, *at finish*.

“Put 8 gallons of water in kettle and start fire. Place lime in kettle. After slaking is well started, add the dry sulphur and mix thoroughly, adding enough water to maintain a thin paste, which requires about 5 gallons. After the slaking and mixing is completed, add water

* Penn. Bulletin No. 92.

† Penn. Bull., No. 92, p. 12.

‡ The author's figures for volume have been changed to Imperial measure.

to the height of 40 gallons on the measuring stick, bring to a boil and stir until the sulphury scum practically disappears. Then add water (preferably, but not necessarily, hot) to the 55 gallon height and boil again to 50 gallons, if storage space is limited. If it is not limited, a little more water should be added the third time and boiling stopped at about 45 gallons. The material should be kept well stirred, especially during the early stages of the process, and any lumps of sulphur or lime should be thoroughly broken up.

"The total time of actual boiling should be about one hour, though a ten-minute variation either way is not objectionable providing the sulphur is evidently dissolved. This fact is best determined by dipping and slowly pouring some of the material. The amounts of water indicated above are ample for one hour's fairly vigorous boiling, with the finishing volumes as indicated. If it is not at the desired height at the close, it may be made so by more water or more boiling, and either the amount of water in the third addition or the vigour of boiling can be so modified in later trials as to enable the total to be brought to the desired height approximately at the end of the hour.

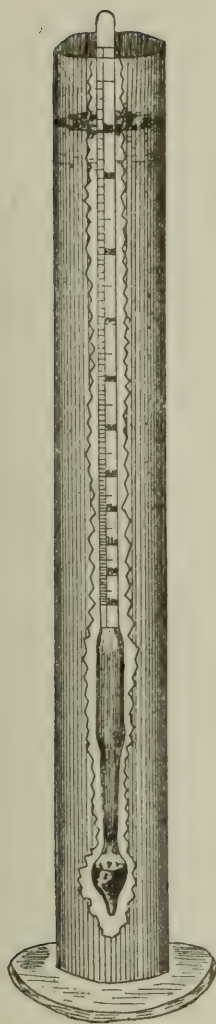
"The finished product may be immediately poured or strained into a barrel or settling tank or into the spray tank. The straining is merely a safeguard to prevent any possible clogging because of imperfect materials or failure to break lumps in the sulphur. When properly made the amount of sediment left in the strainer is insignificant, being less than 1%, as shown in Table I.. and may be thrown away. To avoid any considerable loss of materials, however, the sediment in the strainer can be washed with part of the water used in making the next lot, simply pouring the water through the strainer into the kettle, and any lumps of sulphur discovered may be broken up and used again.

"If the straining is not done, the whole product may be put into a settling tank or barrel, and the clear liquid drawn off later as required. This process, however, is likely to lose efficient liquids in the sludge, as well as the fine sludge itself, which may be of value in several ways, and is of no apparent hindrance in the spraying.

"The crust which forms on the finished material is prevented by immediately covering the solution with a layer of oil about an eighth of an inch thick, and avoiding unnecessary exposure to air in the transfer from kettle to storage tank. An ordinary paraffin oil was very satisfactory in our work, but there is reason to believe that any other oil, not injurious to trees nor likely to take fire at boiling temperatures, may be used with equal success.

"The crust may also be prevented by immediate storage in tight, closed vessels, filling them completely. But partially filled vessels are likely to develop some crust upon continued exposure."

Washes were made, using the above formula and directions, from two of the common limes, Beachville and Port Colborne, and analyzed. The results are shown in Table III.



An hydrometer, a form of specific gravity spindle, very useful in testing the strength of lime-sulphur solutions. It is here shown suspended in a cylinder of water in the same way that it would be suspended in a vessel containing lime-sulphur solution.

TABLE III.—SHOWING THE COMPOSITION OF SOME HOME-MADE LIME-SULPHUR CONCENTRATES.

Sample No.	FORMULA.			Specific Gravity of Clear Liquid.	Kind of Lime.	Length of Boiling Period.	Total Sulphur in Solution. lbs. per gallon.	Sulphide Sulphur in Solution. lbs. per gallon.	Iodine and other forms of Sulphur in Solution. lbs. per gallon.	Per cent. of total Sulphur in Sulphide form.	Amount of Clear Liquid obtained. Gallons.
	Lime. lbs.	Sulphur lbs.	Water. gals.								
158	50	100	40	1.232	Beachville	1 hour.	2.393	2.192	.202	91.6	35.5
159	50	100	40	1.232	Pt. Colborne	"	2.371	2.228	.143	93.1	32.2
160	50	100	35	1.245	Beachville	"	2.670	2.646	.023	99.1	30.7

If this table be compared with Table II., it will be seen that there is not much difference in composition between the commercial concentrated Lime-sulphur solution and the home-made solution. The commercial articles are stronger and denser than the home-made, but the latter could easily be made as high in these respects by merely reducing the quantity of water used. This tendency is shown in No. III. where the quantity of water was reduced by 5 gallons, thereby raising the specific gravity by .013 points and increasing the amount of the sulphur compounds per unit volume to quite an extent. ,

To control the manufacture of the strong solution, it will be practically necessary to use a specific gravity spindle (hydrometer). Especially would the use of this instrument be essential in the experimental stages of making the wash, for it is the only ready means at the hand of the practical man for determining the strength. The manipulations in using the spindle are very simple. All one has to do in getting the density of his wash by this means, is to allow the wash to stand long enough to settle and cool to about 60° F., and then to suspend the instrument in the clear supernatant liquid. The density of the liquid is that reading on the graduated scale just at the surface. The further the spindle sinks into the liquid the less is the density, and *vice versa*.

The specific gravity of a wash also gives the only ready basis for the dilution of the concentrated washes, or for that matter, of any wash. It is pretty well established that unless other substances such as salt, soda, etc., have been used in the manufacture of the Lime-sulphur wash, that the specific gravity varies in nearly direct proportion to the strength, *i.e.*, the denser a wash is the greater the dilution necessary to reduce it to a standard strength. The only exact basis of dilution, of course, is on the sulphur content, especially the sulphide sulphur content, but such a factor can only be determined by chemical analysis.

The specific gravity of the liquid of a well made home-made wash of the 20-15-40 formula will run about 1.028. Therefore, since this wash is very satisfactory, although not by any means an established standard, the foregoing factor can be used as a basis for dilution for a winter spray. Suppose a wash on hand has a specific gravity of 1.200. The amount of dilution which it can stand can be approximately determined by dividing the decimal part of the reading by the decimal part of the reading of the standard. Thus:

.200

— = 7.14. That is, one gallon of the wash when diluted to the

.028

proper strength will have a volume of 7.14 gallons, or, in other words, for each gallon of the wash approximately 6.0 gallons of water must be added in order to get a wash of the correct strength.

For the summer spray, dilution would have to be carried to a much greater degree. It is quite possible, however, that the self-boiled Lime-sulphur wash as recommended by Mr. W. M. Scott, of the United States Department of Agriculture, will become the popular summer spray.

Hydrometers for heavy liquids, ranging from 1.000—1.400, can be obtained from any chemical supply house in Toronto or elsewhere for 75 cents to one dollar. They can be had showing both the Baumé and Specific Gravity scales, but if an instrument is obtained showing only one of the scales, the latter is to be preferred as it gives the most ready means for dilution unless a conversion table for the two standards be at hand.

AMOUNT OF SPRAY SUPPLIED BY THE HOME-MADE CONCENTRATES AS GIVEN IN TABLE III.

When the home-made concentrates—as given in the table—are diluted to winter spray strength, the following amounts of spray will be obtained.

Sample No.	Diluted on sulphide basis— 10.41 lbs. to 40 gallons.	Diluted on specific gravity basis —1.028 for average spray.
158	299 gallons	294 gallons
159	276 “	267 “
160	313 “	269 “

One hundred pounds of sulphur, as in the ordinary home-made wash, of the formula 20-15-40, will make about 266 gallons of spray.

The dilutions in above table are all figured on the volume of clear liquid which would be furnished as indicated in Table III. This amount would vary for different limes and different concentrations, but would be fairly constant when these factors are constant.

If all the concentrate be used, both mud and liquid, then the amount of water added to each gallon would have to be lessened in proportion. The retention of the mud in the spray might be advisable. It does not disturb the keeping qualities of the concentrate, and further, it possesses considerable merit, as elsewhere mentioned.

QUALITY OF LIME USEFUL FOR MAKING THE CONCENTRATE.

Lime of good quality should be used in making the home-made concentrate. Beachville lime (0.6% impurities) is of ideal quality, but Port Colborne (13.6% impurities) is also suitable according to Table III. The purer the lime the greater will be the quantity of strong liquid obtained. Beachville gives 2.8 gallons more than Port Colborne per 40 gallons. Caledon lime with its 8.6 per cent. of impurities would also be suitable. Guelph lime which has 51.2 per cent. of impurities, is quite unsuitable. With it a wash ranging only from 1.100 to 1.126 sp. gravity could be obtained by using the proportion of 1 : 2.

Freshly burnt lime should also be used, because air-slaked lime combines with sulphur very slowly. It is very good for making the ordinary home-boiled wash where the proportion used is usually greater than the sulphur, but for the manufacture of the concentrate it is wholly unsuitable. Air-slaked Beachville lime gave a wash ranging only from 1.140 to 1.153 sp. gravity after one hour boiling. Longer boiling would increase this but such a procedure would be undesirable.

From the conclusions of Professor Stewart, and from the results of our own work, it seems altogether likely that the home-made concentrated Lime-sulphur solution will take an important place in orchard control work. After the initial expense for barrels and storage space has been once covered, the concentrate can be prepared more cheaply than the commercial article can be purchased unless the price of the latter be reduced. It can also be prepared more cheaply than can the ordinary home-boiled wash, as more economy both in lime and fuel is accomplished; it can be made at slack times; and it is ready for spraying at a moment's notice.

THE USE OF ARSENICALS WITH LIME-SULPHUR WASHES.

In view of the fact that Lime-sulphur solutions are beginning to take the place of Bordeaux Mixture for summer spraying for fungus diseases, it is important to know whether arsenicals can with safety be added to them for controlling codling moth larvæ, etc. If they can, then a second spraying operation, which would otherwise be necessary, will be obviated.

The main points to consider in this connection are: (1) Will the wash be decomposed or lessened in strength and activity by the addition of arsenicals, and (2) will the arsenicals be lessened in efficiency or changed in such a way that they would induce foliage injury.

As to the second point, there is little doubt as to the efficiency of the arsenicals being left unchanged, since no arsenic is withdrawn from the field of action. But there is a danger regarding foliage injury. We found that considerable quantities of soluble arsenic, the injurious substance, were present in the spray where arsenicals were used. On tender foliage, such as peach, marked damage might result, but this is a point which can only be settled by actual spraying experiments. Plenty of free lime in the spray will overcome the danger to a great extent, but would not altogether prevent damage on susceptible foliage.

The first point, the effect which the addition of arsenicals will produce upon the strength of the wash, we studied quantitatively. The effect on activity can only be studied by spraying experiments, except in so far as it might be indicated by effect on strength. For obvious reasons the strength of a wash could not possibly be markedly changed—for the amount of an arsenical which would be added would be comparatively so small in amount that the extent of decomposition which it

could bring about would be practically insignificant; but some quantitative estimations were made in order to gain some information on this point. A wash was prepared and divided into several portions. To a separate portion one each of the more common arsenicals was added and then each portion was analyzed for total sulphur in solution. The plan was as follows:

To portion No. I. was added Lead Arsenate, at the rate of 3 pounds per 40 gallons.

To portion No. II. was added Paris Green at the rate of 1 pound per 40 gallons.

To portion No. III. was added Calcium Arsenite at the rate of $\frac{1}{2}$ lb. of As_2O_3 per 40 gallons.

To portion No. IV. nothing was added.

After the arsenicals were added the mixtures were agitated every few minutes for an hour and then at the end of that time analyzed. The following figures show the results:

No.	Arsenical added.	Total sulphur in solution. Lbs. per 40 gallons.	Amount of sulphur removed from solution. Lbs. per 40 gallons.
I.....	Lead Arsenate....	12.587	.067
II.....	Paris Green.....	12.149	.505
III.....	Calcium Arsenite..	12.653	.001
IV.....	Check.....	12.654	....

It will be seen that the amount of sulphur removed from solution is very small when Lead Arsenate or Calcium Arsenite are used—it is removed in insignificant amounts by the latter. But Paris Green causes considerable destruction, slightly over one-half pound of sulphur being destroyed, an amount which would represent from 10 to 40 per cent. of the sulphur which would be present in summer sprays.

There is no reason why arsenicals such as Lead Arsenate and Calcium Arsenite should not be used along with Lime-sulphur washes, should no foliage injury result. Calcium Arsenite would be preferable as it is cheap and effective and can readily be made at home.

SUMMARY.

Data secured in regard to the home-made washes reveal a large number of different formulæ and decided differences in the strength of the wash as applied. Sulphur in the formulæ varies from 15 to 19 pounds, and lime from 16 to 24 pounds to 40 gallons of water. The popular formula is the old 20-15-40 one, and the favourite boiling period is one hour.

Analyses show that the liquid part of the wash consists of a solution of calcium sulphide, calcium thiosulphate and sulphite, and calcium sulphate. The average amount of sulphur in these different forms is 10.41, 3.11 and .37 pounds, respectively, per 40 gallons. The residue or "mud" is composed of lime and very small amounts of free and combined sulphur, together with such substances as iron, aluminium, silica and magnesia, and other impurities in the lime used.

The strength of the wash does not depend upon the formula entirely, but more largely on the *thoroughness* and *rate* of the boiling. Weak, slow boiling will produce a weak wash no matter how much sulphur or lime be used. It is this fact which is accountable for the many conflicting opinions held regarding formulæ and methods of preparation, etc.

Commercial Lime-sulphur solutions contain the same constituents as the home-made washes, except that they lack the "mud," (one exception, see No. 136, Table II). They are therefore of similar origin and value. They are 8 to 10 times or more stronger than the home-made washes, and must be diluted accordingly.

The strength of the commercial Lime-sulphur solutions is controlled by means of the specific gravity, for it has been found that strength and density of the clear solution of lime and sulphur vary in nearly direct proportion. Specific gravity can readily be determined by means of an hydrometer, an instrument which costs but little, and which can be utilized by any one after a little experience.

Further, the hydrometer can be used for controlling the strength of any genuine Lime-sulphur solution, *i.e.*, any solution which has been made by boiling together lime and sulphur in water without the addition, either before or after, of any other material such as soda, salt, etc.

The valuable constituent of the Lime-sulphur wash is the Calcium sulphide (sulphide sulphur), but its effect is ably complemented by the other constituents present. The greatest aid, however, is obtained from the decomposition products—free sulphur and calcium sulphite.

Dry weather during and following the spraying season allows the wash to exert its maximum effect. A heavy rain right after spraying or intermittent showers following every few days will greatly lessen or destroy the benefits of the wash.

From the results of our experiments on the preparation of the home-made wash, we arrive at the following:

(1) Normal limes, ranging from 48 pounds and upwards of pure CaO per 100 pounds, are suitable for making Lime-sulphur wash with a formula of 20 pounds lime and 15 pounds sulphur (or any formula having the proportions, 4 lbs. lime to 3 lbs. sulphur).

(2) *Flour* and *flowers* of sulphur are of equal value for making the wash, provided they possess an equal degree of fineness and purity.

(3) Forty-five minutes to one hour is a sufficient length of time to boil the wash, provided the boiling is *vigorous*.

(4) Increasing the proportion of sulphur to lime up to 1 : 1, or even higher in case of the use of a pure lime such as Beachville, will increase the strength of the wash and decrease the cost of production.

(5) Steam and open fire are of nearly equal value as sources of heat energy for boiling the wash.

(6) The development of a green colour during boiling cannot be taken as an indication of the completeness of boiling with all limes.

(7) If a wash cools and crystallizes before it is applied it is not valueless. Heating up to 60° or 70° C. (140° to 158° F.) and stirring to break up the sediment and crystals at the bottom till the crystals dissolve will render the wash practically as efficient as before.

Experiments carried on in regard to other points show the following:

(a) Home-made concentrated Lime-sulphur solutions comparing favourably with the commercial solutions can be made on the farm and at less expense.

(b) Lead arsenate and calcium arsenite can be added to Lime-sulphur washes without causing any appreciable depreciation in the strength of the latter.

(c) The formation of crystals in Lime-sulphur washes is mainly due to an excess of free lime, but contact with air will also cause concentrated Lime-sulphur solutions to crystallize. If lime be added to concentrated Lime-sulphur solutions, they will suffer extensive crystallization at once. Lime added to diluted concentrates will soon cause appreciable crystallization. Concentrated Lime-sulphur solutions should be diluted first and then the lime added just immediately before spraying.

RECOMMENDATION.

It is very desirable that extensive orchard experiments be carried on, in connection with chemical analytical work, in order that some standard formula for making and preparing a Lime-sulphur wash could be settled on which would at various dilutions cover all cases in question. At the present time there is a great lack of unity and definiteness concerning everything in this connection. Formulæ vary, directions for preparation vary, and even closest neighbours are at variance over the question. There is no doubt but that a standard formula, with specific directions attached, can always be made to produce a wash of constant strength. The flagrant latitudes which are now so general are only producible of constant misunderstandings and controversies which are hard to explain away.

ACKNOWLEDGMENTS.

Credit is due to all the available sources of information which have been used in carrying on this work in connection with the Lime-sulphur washes, and especial thanks are due to Professor Harcourt for the many valuable aids and suggestions given, and for laying the plans of the investigations herein reported.

PART II.

PRACTICAL AND POPULAR TREATMENT.

BY L. CAESAR.

In discussing the lime-sulphur wash from the practical and popular standpoint attention will be given first to the different forms in which the wash may be used, the proper method of preparing each of these, the use of arsenicals with the wash, proper spraying outfits, and hints on spraying. After these subjects have been discussed the remaining space will be devoted to an account of the different insects and fungus diseases which experience has shown may be controlled by the wash, and to specific directions for the proper treatment of each.

THE DIFFERENT FORMS OF THE WASH.

1. Home-boiled lime-sulphur.
2. Self-boiled lime-sulphur.
3. Home-made concentrated lime-sulphur.
4. Factory-made or commercial lime-sulphur.

Of these forms Nos. 1 and 4 are at present by far the most commonly used in Ontario. No. 2 is beginning to be used a good deal, but No. 3 is still in the experimental stage. It promises, however, to become the most popular of all in a few years when further study and experiments will have shown the best method of preparing it, and of determining the proper strength to use in each particular case.

HOME-BOILED LIME-SULPHUR.

This form of lime-sulphur is meant to be used on the trees only when they are dormant or before the buds have actually burst. It is often, however, used without injury when the tiny leaflets have protruded nearly half an inch beyond the bud scales, but it is not safe to use it later than this as it will usually burn the leaves after they are once unfolded. For years this wash has been very popular in the Niagara district and in nearly all the states across the border.

THE PROPER FORMULA. There have been many different formulæ for making it, some much stronger than others. The one most popular to-day is 20 lbs. fresh stone lime, 15 lbs. sulphur and 40 gals. water. If a few trees very badly infested with San José scale are to be treated the proportions are sometimes changed to 25 lbs. lime and from 18 to 20 lbs. sulphur to 40 gals. water. For all ordinary purposes the former

strength is sufficient. In very dry climates still weaker formulæ may be used satisfactorily but it is not advisable to use them in Ontario.

DEVICES FOR BOILING. Many different devices are used for boiling the mixture. It is not at all necessary to have an expensive outfit. A cheap simple one will give as good results. A kettle holding from 20 to 25 gals. water will serve the purpose.

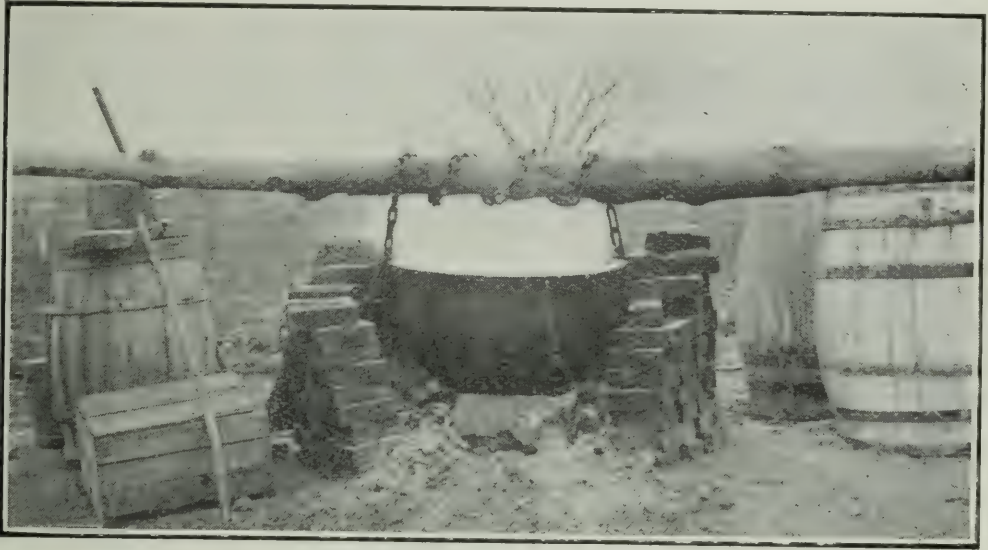


Fig. 1. Kettle used for boiling the lime-sulphur wash.

Fig. 1 shows a kettle that was used by a successful fruit-grower last spring and that gave satisfaction. A more economical device is shown in Fig. 2.



Fig. 2. Wooden box with sheet-iron bottom used for boiling the lime-sulphur wash.

This consists of a stout, close-fitting box with wooden sides and ends and sheet-iron bottom. This box is usually made large enough to boil sufficient of the mixture at one time for two barrels of diluted spray. Each box is about 6 feet long, 3 feet wide and from 14 to 18 inches deep. The sides and ends are made of 2 inch planks closely fitted together at the corners. The sheet-iron bottom should extend slightly beyond the planks to protect them from the fire. It is nailed to them by ordinary wire nails. The box thus constructed is placed on iron bars stretched across a roughly made brick or stone foundation from 14 to 20 inches high with one end open for throwing in fuel, and the other provided with a couple of lengths of stovepipe to create a draught and carry off the smoke. It is found very convenient to place a



Fig. 3. A small steam-generator used for boiling the lime-sulphur wash.

"molasses gate" or faucet with a good sized aperture near one corner to enable the operator to draw off the wash when ready. If this faucet is situated about one-half inch or so above the sheet-iron bottom it will prevent any coarse sediment from passing out, and will thus make the mixture easier to strain. Before using the box it should be filled with water, and let soak a few hours. It is found that the mixture can be made very rapidly in these boxes because of the large amount of surface exposed to the flames. To prevent unnecessary loss of heat there should be a wooden covering made of three or four boards running lengthwise and fastened together by crosspieces near the ends. An opening must be left between the two middle boards wide enough for a hoe handle to run through easily to permit the necessary stirring.

Instead of boiling by direct heat from the fire many prefer to use steam. This is the most pleasant method and the most convenient, especially where a large quantity has to be prepared each day.

If it is desired to boil only two barrels at a time Fig. 3 shows a very convenient little steam generator costing about sixty-five dollars.

Fig. 4 shows an ordinary steam engine of about 12 horse-power which is used to boil from eight to ten barrels at a time.

Fig. 5 shows a still larger outfit where the mixture is boiled in large tanks, each having a capacity of several barrels. The tanks, it will be observed, are placed on a platform, which is a few feet higher than the spray tank, and the wash when ready can flow through a tap and large hose into the screen and be strained directly into the tank, thus avoiding the rather unpleasant task of dipping it out with pails.



Fig. 4. A threshing engine used for boiling lime-sulphur.

It is perhaps necessary to repeat that, although boiling by steam is a very convenient and satisfactory way, it makes no better wash than can be made in the kettle or box or some other cheap device.

Whatever style of boiling plant is used it should be situated in some place that will be dry, easily drained, and yet very close to an abundant water supply. Many persons select some suitable spot near a large ditch or pond where there is usually plenty of water in spring, the time when the boiling is done.

HOW TO MAKE THE WASH. Having decided upon a satisfactory formula and outfit for boiling, the next thing to consider is how to perform the task itself. Let us first suppose that we are boiling a barrel by steam from an engine or other steam generator. First fill the barrel about one-third with either hot or cold water, as is most convenient, and

then turn on the steam to be heating this while the lime and sulphur are being got ready. Place the 15 lbs. sulphur in a large pail or similar vessel and add enough water to make a thick, not sloppy, paste. Stir well to have all the sulphur moistened and the lumps so far as possible broken up. Then weigh out 20 lbs. good fresh lime. Drop this into the boiling water in the barrel, and when it has begun to slake vigorously add the sulphur paste. During the slaking the steam from the engine should be turned off for a few minutes until the very violent boiling ceases sufficiently to allow its being turned on again without causing too much of the liquid to splash out of the barrel. The boiling must be continuous and very vigorous throughout. Frequent stirring is necessary to help the sulphur to combine with the lime and to prevent



Fig. 5. An outfit for boiling the lime-sulphur in large quantities.

sediment being left over. If the boiling is vigorous forty-five minutes will be long enough; it is wiser, however, in most cases to boil for one hour. Too much emphasis can scarcely be placed upon the necessity for vigorous boiling. So vigorous should it be that the liquid will splash up to the top of the barrel. To prevent its splashing out an old sack or a couple of boards should be placed over the barrel. This will also help to keep the heat in. Many writers have said that boiling must be continued until the liquid reached a certain color. This is not at all a safe rule; for colour depends almost entirely upon the kind of lime used, different kinds of lime often producing different colours.

Where the boiling is done in a kettle or box practically the same method of procedure is followed. It is impossible to give specific directions for the exact amount of water to use, but the principle on which

to go is, that the smaller the amount of water the sooner the boiling will be done. There should always, however, be at least 12 gals. water for each 40 gal. barrel of diluted spray. In the box, on account of the large amount of surface covered, a considerably larger quantity will be found necessary. The very rapid evaporation from the kettle or box will require the addition of a little extra water from time to time. If the mixture threatens to boil over add cold water.

As soon as the wash has been boiled sufficiently long it should be diluted to the full 40 gals., or whatever multiple of this is required. This may be done with either hot or cold water. If cold water is used it is better to pour it directly into the vessel in which the boiling is being done, so that the heat of the vessel itself may be utilized in maintaining a higher temperature. A hot or fairly hot spray passes through the nozzles better than a cold one and seems in a number of cases to have given considerably better results.

As soon as the proper amount of dilution has been made the liquid should be strained through a wire screen of not less than 20 meshes to the inch. The wash should then be applied to the trees at once.

If for any reason it is necessary to allow a barrel to stand over until the next day it should be re-boiled for a few minutes until all the little orange crystals are dissolved. These crystals form as soon as the wash gets cold, and if not brought into solution they would by clogging the nozzles make spraying almost impossible and would weaken the wash by separating some valuable substances from it.

THE COST. The cost of a 40 gal. barrel of this wash is not very great. If a number of men in a district club together and buy their lime and sulphur in large quantities they will get the lime for about 25 cents a bushel and the sulphur for about \$1.50 per cwt. or $1\frac{1}{2}$ cents per lb. At these prices the cost per barrel apart from the labour and fuel would be about 9 cents for lime and 23 cents for sulphur, a total of 32 cents.

SELF-BOILED LIME-SULPHUR.

This wash has been brought into prominence lately by Prof. W. Scott of the Department of Agriculture, Washington, D.C., who has used it chiefly on peach trees to control the Brown Rot and Scab. He advises using the formula 10 lbs. good fresh lime, 10 lbs. sulphur and 40 gals. water. His directions for making the wash are as follows: "The mixture can best be prepared in rather large quantities—say 20 lbs. or even 40 lbs. at a time—so as to get enough heat to produce a violent boiling for a few minutes. Place the lime in a barrel and pour enough water (about 3 gals. per 20 lbs.) to start it slaking and to keep the sulphur off the bottom of the barrel. Then add the sulphur which should first be worked through a sieve to break up the lumps, and finally enough water to slake the lime into a paste. Considerable stirring is necessary to prevent caking on the bottom. After the violent boiling which accompanies the slaking of the lime is over the mixture should be

diluted ready for spraying, or at least enough cold water added to stop the cooking. Five to fifteen minutes are required for the process according to whether the lime is quick acting or sluggish. Only a small percentage of the sulphur—enough to improve the adhesiveness of the mixture—goes into solution, but if the hot mass is allowed to stand as a thick paste the sulphur continues to unite with the lime, and at the end of thirty or forty minutes enough of the reddish liquid is produced to burn peach foliage and even apple foliage in some cases. Hence the necessity for cooling the mixture as soon as the lime is well slaked.”

The writer has used a good many barrels of this wash this summer and found it very easy to prepare. For use on apple foliage he used boiling water to slake the lime instead of cold water. To stir the mixture while boiling, a hoe was found satisfactory. With it the lime should be raised merely a little way from the bottom to let the water down and so prevent caking. It should not be brought to the top as that tends to check the boiling. The stirring must not begin until slaking has got well started. For peach trees 8 lbs. lime and 8 lbs. sulphur are reported to be equally as satisfactory as 10 lbs. of each.

As there is a great deal of sediment in this wash it can be strained much more easily if first diluted to almost the total amount. The same sort of screen may be used as for home-boiled wash.

When applying the wash to the trees extra precautions should be taken to see that it is kept well agitated.

The cost per barrel at the prices of the materials given is very low: lime 5 cents, sulphur 15 cents, total 20 cents.

HOME-MADE CONCENTRATED LIME-SULPHUR.

If any attempt is made to store the ordinary home-boiled lime-sulphur, either in a somewhat concentrated or a dilute condition, orange crystals form in large numbers and make it necessary to re-boil the mixture to dissolve them before it can be applied to the trees with the best results. That a concentrated wash can be made and stored without crystallization and that it may have practically the same high insecticidal and fungicidal value as the home-boiled, has been shown by the lime-sulphur sprays put on the market by several commercial companies. These commercial washes are, however, costly, especially for spring work; consequently efforts have been made by experiment stations to discover a satisfactory formula for making a home-made concentrated wash that will be of as high merit as those sold by the different companies, and very much cheaper. Several formulæ have from time to time been proposed. Prof. J. P. Stewart, of Pennsylvania, took up the problem last year and tested many formulæ until he discovered one that seemed to be quite satisfactory. The formula recommended by him is 25 lbs. lime, 50 lbs. sulphur and 20 gals. water boiled one hour. Only lime with a high percentage of calcium must be used. Such lime can be obtained from either the Beachville or Port Colborne lime dealers. Any

of the devices for boiling mentioned in describing the Home-boiled Lime-sulphur may be used. The general method of procedure indicated there may also be followed. Care should be taken to stir very frequently, and to see that whatever water has evaporated during the hour's boiling is replaced by the addition of fresh water. A measuring stick is a convenient guide. As soon as the wash is boiled, it should be strained through a screen of 30 meshes to the inch and stored in barrels which should either be completely filled and tightly covered or have oil poured over the surface of the liquid to the depth of one-eighth of an inch to keep it from exposure to the atmosphere; otherwise it gradually deteriorates. The barrels must of course be stored in some place where there is no danger of freezing.

For use on trees before the buds burst, it is claimed that a wash of this strength may be diluted about seven times; that is, to every gallon of the wash seven gallons of water may be added. Of course it may be used stronger than this, and in the case of trees badly infested with scale it will be better to dilute it only five times. For use on foliage it must be diluted much more than this. Apple and pear foliage will probably stand a strength of 1 gal. of the mixture to 24 gals. water; other kinds of foliage, especially the peach, are tenderer. These rules for dilution are not to be relied upon implicitly, but rather taken as suggestions. Each fruit grower is advised to test different strengths and find out for himself the ones that are safe and give good results. Prof. Stewart strongly advises that instead of determining the strength by any such rules as those given, an instrument called the *hydrometer* should be used. This gives the specific gravity of the wash and thus enables one to be sure in each case of the exact strength of every barrel that is being made ready for spraying. Directions for using the hydrometer will be given in the Chemistry part of this bulletin. There is very little doubt that before long it will be considered almost indispensable, and will be a great boon to the fruit growers in helping them to obtain uniform results.

Note. As the writer has not had an opportunity to test for himself the home-made concentrated wash, and as it has been very little tested by anyone in Ontario, he will, when describing later how to treat the different insects and diseases, confine his attention to the washes that have been fairly well tested. He hopes, however, that many persons making use of the information given above will co-operate with him in testing the wash, and send in reports of the degree of success which they may have, so that in a year or two the joint information gained will make it possible to give reliable directions for the use of the concentrated mixture to the fruit growers of the Province.

COMMERCIAL OR FACTORY-BOILED LIME-SULPHUR.

Very little need be said about the commercial or factory-boiled lime-sulphur at this stage. It will be referred to frequently later. When first the different brands of this wash were put on the market it was doubted

whether they would give satisfactory results, but numerous tests have shown that many well-known brands are washes of genuine merit. They are gaining popularity very rapidly. No wash could be in a much more convenient form for use than these, as all that is required is to dilute them with water to the proper strength. Directions for dilution are given on each barrel. When applying the wash before the buds burst it is often necessary to use it considerably stronger than the directions state, especially if the pest aimed at is a very serious one, like the San José Scale. The addition of from 10 to 20 lbs. of fresh lime to every barrel of the diluted wash is an advantage in many cases, particularly when any kind of scale insect is being treated, as the lime itself has considerable merit as an insecticide and helps to show clearly whether the trees have been thoroughly covered with the spray. The lime should always be slaked before putting it into the diluted wash and the latter must then be applied at once or orange crystals will form. The one real objection to the commercial washes is the cost. If home-made concentrated lime-sulphur fulfils our expectations there is little doubt that it will be used by many in preference to the commercial as very much more economical.

THE USE OF ARSENICALS WITH LIME-SULPHUR.

Every fruit grower will aim at spraying his trees just as few times as are necessary to keep them healthy and the fruit free from injury by insects or fungus diseases. When using Bordeaux mixture to control the diseases he knows that he may safely combine with it arsenate of lead, Paris green, or arsenite of lime, and thus control at the same time a number of injurious biting insects, such as Canker Worms and the Codling Moth larvæ. This combination of an insecticide and fungicide lessens the total amount of spraying by nearly one-half. Consequently it is a very important matter to know whether any or all of the poisons mentioned above may be combined with the same degree of safety with the different kinds of lime-sulphur washes. With the self-boiled wash numerous tests prove that any one of the three poisons referred to may be safely used. With the home-boiled wash, which is only to be used before the foliage appears, there will seldom be any need of adding a poison, and if need for it should arise what is said about commercial lime-sulphur will apply to it also. The main question then is—what poisons, if any, may be combined with the commercial lime-sulphur? It does not seem desirable to use Paris green, because, while a few have done so and caused no injury to fruit or foliage, others have suffered considerably. Arsenate of lead seems to be much safer. It has been used in numerous instances and nearly always without any sign of damage. In the few cases where it has burned the foliage the injury was so insignificant as to be almost negligible. Possibly the addition of a few pounds of lime to each diluted barrel just before spraying would lessen the danger. If arsenate of lead is used it should be at the strength of from 2 to 3 lbs. to every 40 gals. of the diluted mixture.

Our chemists, however, tell us that the chemical reactions that take place when arsenate of lead is added to lime-sulphur in all probability make its sticking qualities no better than those of arsenite of lime. In this case it is wise to use the latter, especially as it is only about one-quarter as expensive. In limited trials made with it at Guelph on apples and pears it showed no signs of burning the foliage and controlled Codling Worms very satisfactorily. Prof. tSewart strongly urges that it be used in preference to arsenate of lead as equally effective and also cheaper and safer. The following is the substance of his improved method of making it.

HOW TO MAKE ARSENITE OF LIME:

White arsenic, 2 lbs.
Sal soda crystals, 2 lbs.
Water, 1 to 1½ gals.

Add the white arsenic and sal soda to the water and boil with frequent stirring until all the arsenic is dissolved. This usually requires about 15 minutes. Then add three or four pounds of good fresh lime and boil a few minutes, letting the lime slake in the boiling liquid. After this remove the vessel from the fire and add enough water to bring the total up to 2 gals. Each quart of this mixture, if thoroughly stirred, will then contain one-fourth pound of the white arsenic or one-eighth of the original 2 lbs. This amount is ample for 40 gals. spray for Codling Moth and other biting insects, in fact where drenching sprays are used it would be better to use a little less than one quart. As much of this arsenite of lime as is likely to be required for the summer's work may be made up at one time and stored away. Care must of course be taken to label the barrel "POISON," and to see that the white arsenic itself is not left where it may be mistaken for some other substance. Serious accidents have occurred from carelessness of this kind. The barrel should be kept tightly covered, lest the stored liquid evaporate and thus render it impossible to determine the proper strength to use. Always stir thoroughly before measuring out the quantity desired.

HINTS ON SPRAYING OUTFITS.

Before discussing the different insects and diseases that may be controlled by lime-sulphur it seems advisable to devote some attention to spraying outfits and spraying itself.

The first requisite for good spraying is a satisfactory spray machine. Experience has shown that for large trees, or even for medium sized trees, if at all close together, traction machines which furnish the power by means of the wheels are not satisfactory. The reason is simply that they do not keep up sufficient pressure to permit a thorough job to be done in every case. No machine should be purchased which will not allow the operator to remain as long as he desires at any tree and which

will not enable him to maintain a uniform pressure all this time. The conditions are satisfactorily met where the pressure is generated either by a hand pump or gasoline engine, or by one of the new styles of compressed air sprayers which have recently been introduced into a few districts in the United States and are said by good authorities to be likely to become very popular in a few years.

Among the best known manufacturers of spraying machinery are the following:

The Sframotor Co., London, Ont.

The Goulds Manufacturing Co., 91 Fall St., Seneca Falls, N.Y.

The Friend Manufacturing Co., Gasport, Niagara Co., N.Y.

For a small orchard of not more than five or six acres the simple barrel outfit with the best quality of hand pump that goes with it gives fairly good satisfaction. Such outfits should not cost more than \$20.00 if a number of farmers club together and purchase them at the same time.

For larger orchards tanks holding 120 to 200 gallons and equipped with powerful double acting pumps or with gasoline engines are required. A good gasoline engine in a large orchard will pay for itself in a couple of years by the amount of hand labour it saves.

In almost every case a spray machine should be provided with two lines of hose and two extension rods with their complement of nozzles. The one line of hose is used by a man on the ground, the other by a man on a tower for large trees, or on the tank itself for medium sized trees. It is not always necessary to use both lines of hose but they should be available whenever needed. The hose should be of good quality, capable of standing a pressure of 200 lbs. The one for the tower should be from 10 to 12 feet long, the other from 20 to 25 feet.

Bamboo extension rods are the most common kind. It is desirable to have them of different lengths, one from 6 to 8 feet, the other 8 to 10 feet. Occasionally, where an attempt is made to do without a tower, rods of from 12 to 14 feet in length are purchased.

The selection of the nozzles is a very important matter. The most popular kind of nozzle is probably one of the Friend type. Plates with different sizes of holes may be got for use in these nozzles and thus a coarse or fine spray can be secured at will. Each nozzle of this kind costs \$1.00. Often it is advisable to use two nozzles on a V at the end of the extension rod.

Another good kind of nozzle is the ring cluster with either 4 or 8 nozzles to the ring. These give a beautiful mist spray, but are too much inclined to clog if there is any appreciable amount of sediment in the wash.

A cluster of Vermorel nozzles also gives a good mist spray but is somewhat heavier than the ring cluster and is inclined to get entangled among the branches to the annoyance of the sprayer. It also is inclined to clog with thick washes.

In most cases it is a great benefit to have the nozzles set at an angle of about 45° to the extension rod. This enables the operator to control the direction of the spray, and is especially important when spraying for the Codling Moth as it makes it possible to send the spray directly into the open calyx, thus coating every part of it with the poison. The Spramotor Co., London, manufactures a small brass elbow (Fig. 6), costing 20 cents, which is very light and convenient and can be inserted in a minute or two between the extension rod and any kind of nozzle. Ring cluster nozzles are already set at an angle, and so do not require an elbow.

A good strainer is another important part of the outfit. This is usually made of brass wire, but a cheaper kind will do as well for lime-

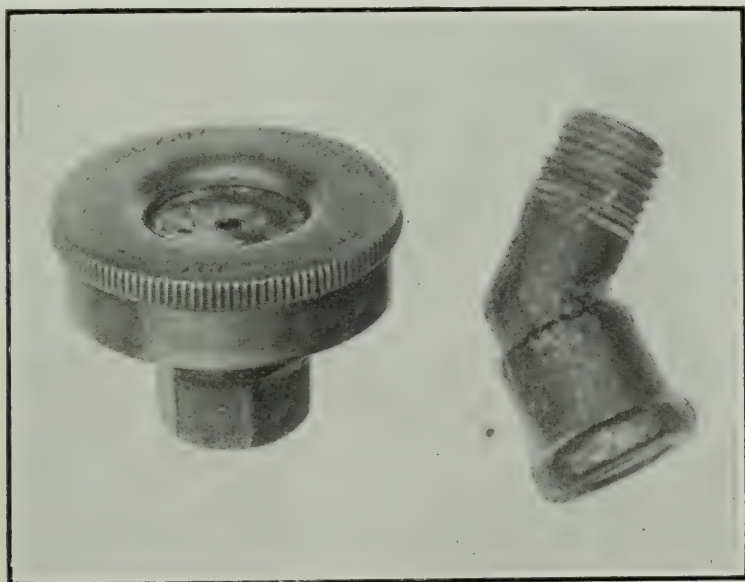


Fig. 6. Friend type of nozzle, and a small elbow found very desirable in spraying. Both natural size.

sulphur though not for Bordeaux. Usually a strainer is purchased with the spray machine. They are of various shapes, some having the wire in the form of a cone in an ordinary galvanized-iron pail with a large funnel fixed in the bottom for the liquid to pass through into the spray tank; others have a sheet of wire fastened obliquely across the lower part of a nearly rectangular vessel of at least a pail's capacity, the liquid passing out through a funnel; others are made by merely attaching the wire close to the bottom of a small hopper with sloping sides that fits tightly into the opening in the spray tank. The sieve should have at least 20 meshes to the inch, and if the liquid is fairly free from sediment 40 meshes or even 50 may be used. Wire-cloth of any required number of meshes to the inch may be purchased from the Wire Goods Co.,

King William Street, Hamilton, Ont., or from other manufacturers. The screen should always be washed after it is used, and it is well to leave it in the water between loads.

Those who intend purchasing a spray outfit should write for catalogues to any of the companies mentioned above, or to others, and in these they will see good illustrations of all the different parts referred to above, and of others that it would require too much space to discuss here.

The best pressure to use is a disputed point. No one advocates less than 100 lbs. and a few advocate as high as 200 lbs. With most spray pumps it is found fairly difficult to maintain a steady pressure of 100 lbs., but whenever it is possible without excessively hard labour to secure a higher pressure the spraying can be done more thoroughly and

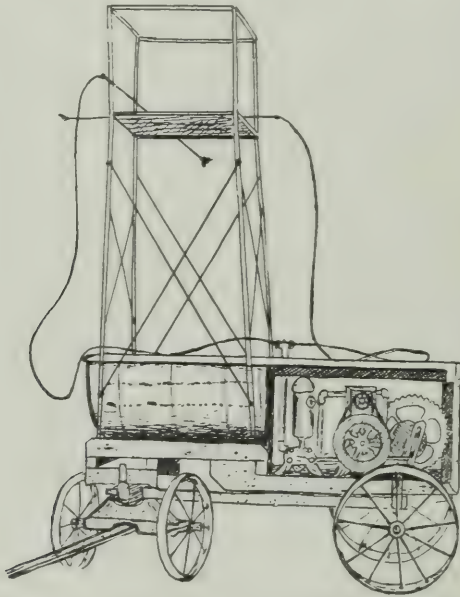


Fig. 7. Tower and spray-tank with gasoline engine.

rapidly, especially on large trees after the foliage has appeared. In purchasing a gasoline engine it is well to stipulate that it shall be able to furnish 200 lbs. pressure if desired. Of course high pressure requires a good strong hose but this can be obtained. The writer used 200 lbs. pressure for several days this summer without any sign of the hose giving way.

HINTS ON SPRAYING.

If spraying is to pay well it must be done with the right mixture properly prepared, at the right time, and thoroughly. In the pages that follow the different insects and diseases for which lime-sulphur is a fairly satisfactory remedy will be mentioned. The proper time and form of the wash to use for each of these will also be stated, so that we shall confine our attention here to the thoroughness of the work.

It should scarcely be necessary to say that unless the farmer has a very intelligent and reliable assistant he should himself oversee the spraying and make sure that the work is being well done.

There are certain occasions when it is unwise to spray: Lime-sulphur should not be applied when the temperature is below freezing point, or while the trees are wet with rain or dew. Moreover, if a rain follows in a few minutes after spraying and before the mixture has time to dry it will wash the spray off and the operation will have to be repeated. Ordinarily the wash dries in about an hour so that it is seldom necessary to respray because of rain. Long continued and frequent rains, of course, gradually wash the spray off, and are sometimes the cause of poor results.

Spraying should in nearly every case be done with the wind. Hence, one side of the trees will be sprayed first and as soon as the wind changes, the other side. A wind is often of decided benefit in applying the wash, especially to large trees. A very strong wind will doubtless waste a little of the mixture, but it is very seldom that there is any need of stopping operations because of its violence.

When spraying the first side of large trees stop the waggon just as it comes within a few feet of the tree and do the nearest side as far in as the spray can be driven; then drive directly opposite and spray all the central part thoroughly; again move until just past the tree, and now spray this last part as far in as possible before leaving. In this way nearly two-thirds of the tree will have been covered, and when the wind changes it will be easy to make a good job of the rest. A tower is always necessary to do the topmost parts of these large trees.

As it is very important to cover every twig and branch many fruit growers take some of the wash a couple of days after the orchard has been done, and go up and down the rows touching up places that have been missed. This is a most desirable practice in the spring application and serves also to show whether the work has been thoroughly done.

In spraying after the foliage has appeared many are misled by the advice that is often given to stop spraying just before the leaves begin to drip. It is impossible to spray a large or even medium sized tree thoroughly without a considerable amount of dripping. Hence the first rule to follow is, *Make sure that every leaf and fruit is covered*, and second, *Try to do this with as little material as possible*. We cannot expect the spray to keep scab off our apples unless the apples are first covered with the spray.

As spraying apparatus is costly and easily gets out of order, if neglected, it will be wise to wash the tank out each night with clean water and also to pump some of this through the nozzles. Unless washed out in this way lime-sulphur corrodes the brass. Many make a practice of unscrewing the nozzles each night and putting them into kerosene or some other oil to keep them from getting set so firmly that they can only be moved with a wrench.

Another matter requiring attention is the packing of the pump. Frequently this gets worn and then the power cannot be kept up, or only with extra labour. In such cases new packing must be put in. This every fruit grower should learn how to do, and if possible should require the company from which he buys the outfit to send a man to teach him the proper way before he begins to use the pump at all.

As lime-sulphur is quite caustic and will soon make one's hands sore it is important to see that all connections are tight so that there may be no leakage to cause the hands to become wet with the liquid. The ordinary clamps often fail to give as tight a connection between the pump and hose, or hose and extension rod, as can be got by using tough wire about half the size of fence wire and tightening it up with nippers. If the wire is of good quality, and two or three separate bands are put on a very secure connection may be made. Vaseline is used by some to keep the hands from being injured; leather gloves are used by others. A few use rubber gloves but they are too expensive. The horse and harness may be protected by a light cover.

INSECTS THAT CAN BE CONTROLLED BY LIME-SULPHUR.

Having discussed the different forms of lime-sulphur, the methods of making each, the use of arsenicals with the wash, and a few points about spraying outfits and spraying itself, let us now turn our attention to the wash as an insecticide and fungicide, taking up its insecticidal value first.

SAN JOSÉ SCALE.

(*Aspidiotus perniciosus*, Comst.)

Although the San José scale is a very tiny insect, not nearly so large as the head of a pin, it is capable, if not kept under control, of completely destroying whole orchards in a very few years. Fortunately many of our best fruit growers in districts where this scale has been for many years have learned how to keep it so thoroughly in check that they do not fear it at all, and even think it a blessing in disguise, because it has forced them to use a wash which has greatly helped their trees in other ways than merely by destroying the scale. Of the many spray mixtures which have been tried against the scale none has given so uniformly good results as lime-sulphur; so that it is to-day almost the only wash used to any extent for combatting this pest.

Treatment: Spray very thoroughly in spring, as late as time permits before the buds burst, with either home-boiled lime-sulphur or with commercial lime-sulphur. If the latter is used it is often necessary to make it considerably stronger than the directions state, and it is wise to add about 20 lbs. of fresh lime to each 40 gal. barrel of the diluted mixture. The lime should be slaked, preferably with hot water, before adding it to the wash. Of the two forms of the wash the preference

should still be given to the home-boiled, although in many cases the commercial wash has given very good results. It has, however, two defects, first, it cannot be applied hot, and second in a wet spring it washes off the trees much more quickly. It is believed, and apparently with very good reason, that the persistence with which the home-boiled remains on the trees is no small factor in the control of the scale.

Very badly infested trees should receive two applications. These may both be made in the spring with an interval of a couple of days or more, or one may be made in autumn, as soon as the leaves have nearly all fallen, and the other in spring. Very large apple trees are hard to



Fig. 8. San José scale on Pear, showing full-grown and immature scales. Natural size.

keep free from the scale, much harder than smaller or medium-sized ones. To make it easier to treat them thoroughly fruit growers in infested districts are heading the trees back severely. In doing this care should be taken to make a sloping cut in large upright branches, so that the rain will run off, and to see that the wound is thoroughly painted over to prevent disease getting in and destroying the trees. It need scarcely be said that all the pruning of trees should be done before spraying, and that all prunings should be burned, not thrown into brush-heaps and allowed to remain there. If the loose bark be scraped off with a hoe early in the season it will allow the spray to reach scales that otherwise

might escape. Careful cultivation and a liberal use of manure will assist the spray in giving renewed vigour to badly infested trees.

There is no insect, in Ontario at least, that requires more careful and thorough work on the part of the sprayer if he is to get good results, because, if even a few infested twigs are left unsprayed, there will frequently be enough scale on them to produce great numbers by autumn. Hence, after spraying both sides of the trees carefully, it is always advisable to take an extra tankful of the mixture in a day or two

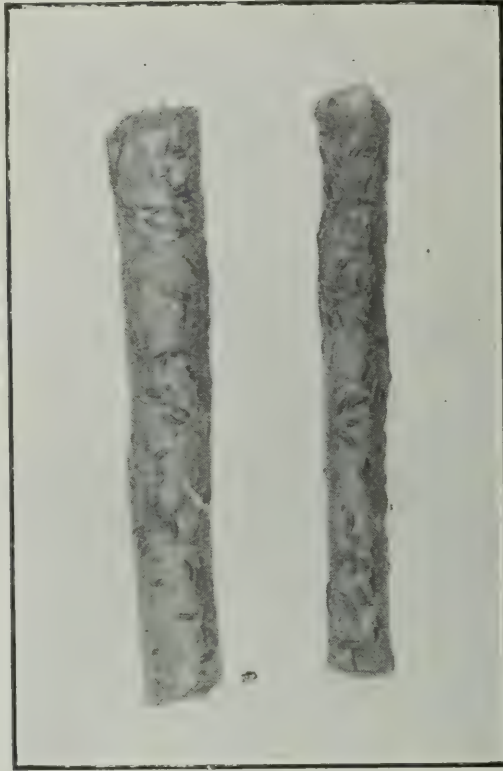


Fig. 9. Oyster-shell scale. Natural size.

and go up and down the rows touching up any poorly sprayed places and seeing that every part of the tree above ground is white with the wash.

OYSTER-SHELL SCALE OR APPLE BARK-LOUSE.

(*Lepidosaphes ulmi*, L.)

Though not nearly so destructive an insect as the San José, the Oyster-shell scale is doing nearly as much damage to the province as a whole, because it is found in almost every orchard, whereas the San José scale is still almost entirely confined to a few south-western counties.

Treatment: Spray in spring, as late as convenient, before the buds have actually burst, with home-boiled lime-sulphur. This wash has given the writer very much better results than the commercial lime-sulphur applied at the same date, though a number of persons claim very good results from a spring application of the latter. If it is used do not dilute to the full amount, and add lime as recommended for San José scale.

A second spraying early in June when the eggs are seen to have hatched and the young creamy white insects are observed running about on the twigs, branches and trunk will destroy great numbers of these. For this purpose use commercial lime-sulphur about 1 gal. to 30 of water, or as strong as experience shows the foliage will safely stand. Lime may be added or not.

Though lime-sulphur is an excellent wash for the Oyster-shell scale it is seldom that any one application will kill more than about 80 or 85% of the eggs, but orchards that are sprayed two or three years in succession with the home-boiled mixture become at the end of that time almost entirely free from this insect.

The commercial wash applied just as the young had all hatched gave unexpectedly good results in the writer's experiments this summer. This treatment would, however, often mean making an extra spraying soon after the regular one for the Codling Moth, and so the spring application with home-boiled lime-sulphur should be relied upon in most cases.

It ought to be kept in mind that this scale is usually much more abundant on trees that are not thrifty; consequently by fertilizing and cultivating orchards the trees will become more vigorous and better able to resist attack.

OTHER SCALE INSECTS.

There are a number of other scale insects that attack orchard trees, such as the New York Plum scale (*Eulecanium cerasifex*, Fitch.), Curtis Scale (*Aspidiotus ostreaciformis*, Curt.), Putnam Scale (*Aspidiotus ancylus*, Putn.), and Scurfy Scale (*Chionaspis furfura*, Fitch.). The same treatment as for San José or Oyster-shell scales will keep these in check. Hence, it is clear that lime-sulphur is a good remedy for almost all kinds of scale insects.

LEAF BLISTER MITE.

(*Eriophyes pyri*, Scht.)

The Leaf-blister Mite is a very tiny insect, so small that unless a number are clustered together they are invisible to the naked eye. In spite of their diminutive size they make their presence very noticeable on both apple and pear trees by causing numerous spots on the leaves. These spots are often confused with fungus diseases, but can easily be distinguished by their being slightly raised beyond the lower surface of

the leaf. As the name indicates they are blisters or swellings in which the mites live and reproduce. Affected leaves are quite conspicuous in the fall of the year. On the apple leaves at this time the blisters are reddish brown in colour and visible on both the upper and lower surface. On the pear leaves they are usually more clustered along the mid-rib than on the apple and become nearly black, often disfiguring the foliage very greatly and being visible several rods away.

The Blister Mite has gradually been spreading all through the province, and is now found in numerous orchards. It does not, so far as



Fig. 10. Work of Blister Mite on leaves of apple and pear. Natural size.

we know, cause the tree to die but weakens it greatly by interfering with the power of the leaves to perform their proper function of manufacturing food for the rest of the tree.

Treatment: The mites cannot be killed while in the leaves, but fortunately they desert these late in autumn and pass the winter under the bud scales. Here they may be destroyed by either home-boiled or commercial lime-sulphur applied in the spring preferably just as the buds are almost ready to burst. The writer sprayed very badly infested pear trees last spring after the buds had burst, but before the leaflets had

opened up. Every mite was destroyed by the one application. It is seldom possible to get so good results as this, especially on apple trees, but thorough work will give excellent results.

PEAR PSYLLA.
(*Psylla pyricola*, Forst.)

The Pear Psylla is also a tiny insect but larger than any yet mentioned. The adult is about one-quarter of an inch long, measuring from the head to the end of the folded wings. It is reddish crimson in colour and has clear wings. The eggs are orange yellow, and are laid on the twigs in spring before the leaves appear. It is the little nymphs which hatch from these that do most of the injury by sucking the juices from the leaf-stems and leaves. As they work they exude an enormous amount of honey dew.

A few years ago this insect threatened to cause much damage to pear trees in the Niagara district, but since the use of lime-sulphur has become common it has ceased to give any trouble in sprayed orchards.

Treatment: Use either home-boiled or commercial lime-sulphur in spring, at the same time as for the San José scale.

APHIDS.

Most kinds of fruit trees in the early part of the season are subject to attacks of Aphids. Apple trees were severely attacked this summer by one or more species of green Aphids. These and many other kinds of Aphids deposit eggs late in the autumn on the twigs and smaller branches. It is from these eggs that the next season's insects come. Hence, if the eggs, which are very tiny and usually glossy black, can be destroyed we may hope to be very little troubled by the Aphids the succeeding season.

Treatment: The writer has not yet entirely satisfied himself that the eggs can nearly all be destroyed by lime-sulphur, but other entomologists who have experimented much more extensively assure us that the lime-sulphur is a reliable method of control. Weak washes, however, are not reliable. Home-boiled of the strength of 25 lbs. lime and 18 or 20 lbs. sulphur to 40 gals. of water is preferable to the ordinary 20, 15, 40 formula. If the commercial wash is used it will require to be proportionately strong. The spraying should be done shortly before the eggs hatch. This takes place usually about a week before the buds burst.

In cases of severe infestation the lime-sulphur should be supplemented by a spray of kerosene emulsion of the ordinary strength applied just as the buds are about to burst. Some fruit growers claim that if the watersprouts and suckers are sprayed with kerosene emulsion

about the end of September it will destroy the Aphids before they can lay their eggs, and so will secure their control for the following season.

SPRUCE GALL-LOUSE.
(*Chermes abietis*, Linn.)

So many enquiries have come to the department of Entomology for the best remedy for the Spruce Gall-louse that it seems desirable to mention here that contrary to the writer's expectation one thorough application of the home-boiled wash applied the first week in May exterminated these insects on Mr. J. W. Smith's beautiful spruce hedge at Winona. The date above given or the last week in April is the proper time to do the spraying.

RED SPIDERS.
(*Tetranychus sp.*)

In dry seasons Red Spiders by working on the underside of the leaves and sucking the juices from them cause much injury to plants of various kinds. We have not tested lime-sulphur for this insect but have good reason to believe we are safe in recommending that a weak wash of commercial lime-sulphur be tried. Probably 1 gal. to 80 of water would be strong enough in most cases. This wash should also be tested in poultry houses for the destruction of chicken mites. Drench the roosts and every part of the interior, keeping in mind that the mites only attack the birds at night and hide in crevices on the roosts and in various other places nearby during the daytime. A strength of 1 to 25 may be used in this case.

FUNGUS DISEASES THAT CAN BE CONTROLLED BY
LIME-SULPHUR.

For most fungus diseases of plants Bordeaux is probably the best spray mixture that is known to-day but in a number of cases lime-sulphur is giving just about as good results and in a few perhaps even better. It can moreover be used with safety in certain forms on trees with very tender foliage like the peach where Bordeaux mixture, even when greatly diluted, often causes serious damage. Furthermore, in some seasons Bordeaux causes a good deal of russeting of fruit which detracts from its appearance and occasionally lessens its selling value. This russeting can be avoided by the use of lime-sulphur. We do not however, advise those who have been getting good results from Bordeaux to change to lime-sulphur.



Fig. 11. Peach Leaf-curl.



Fig. 12. Peach tree almost defoliated by the Leaf-curl disease.

PEACH LEAF CURL.

(Exoascus deformans, (Berk.) Fckl.)

All peach growers are familiar with this fungus disease which causes a thickening and curling of the leaves in the early part of the season. In cold wet springs the leaf-curl is very severe and does a great deal of damage.

Treatment: Spray with lime-sulphur, either home-boiled or commercial, but preferably home-boiled, when the buds are just beginning to swell, or earlier. If the spraying is left off until the buds are almost ready to burst the disease sometimes gets a start and unsatisfactory results follow.

Bordeaux applied at the same time of year also gives good results, but, of course, has no insecticidal value.

BROWN ROT OF PEACH.

(Sclerotinia fructigena, (Pers.) Schrot.)

The Brown Rot of the Peach is the same disease as causes the rotting of plums and cherries. It is so familiar to every peach grower that it requires no description. The disease is apparently not so severe in Ontario peach orchards as in some parts of the United States, but it often causes the loss of a great many peaches in the province. Professor Scott's experiments have shown that it can be controlled.

Treatment: (1) If the Plum Curculio is abundant use for its destruction arsenate of lead, 2 lbs. to 40 gallons of water, and apply as soon as the fruit is set. It is very important to control the curculio as the Brown Rot spores often get into the fruit through the punctures it makes.

(2) Spray three times with self-boiled lime-sulphur, 8, 8, 40 formula. The first application should be about four weeks after the blossoms fall, the last about the same length of time before the fruit ripens, and the middle application about half way between these two.

(3) The destruction of the mummied peaches (Fig. 13.) in late fall or winter will help considerably to make the control of the disease easier, as these are always sources of infection.

Before commercial lime-sulphur can be recommended for this disease or Peach Scab a good many more tests will have to be made. If used it must be very much diluted, at least as much as 1 gal. to 100 gals. of water. Even this strength has been known to do considerable damage.



Fig. 13. Mummied fruit on plum and peach due to the Brown Rot.
About one-half natural size.

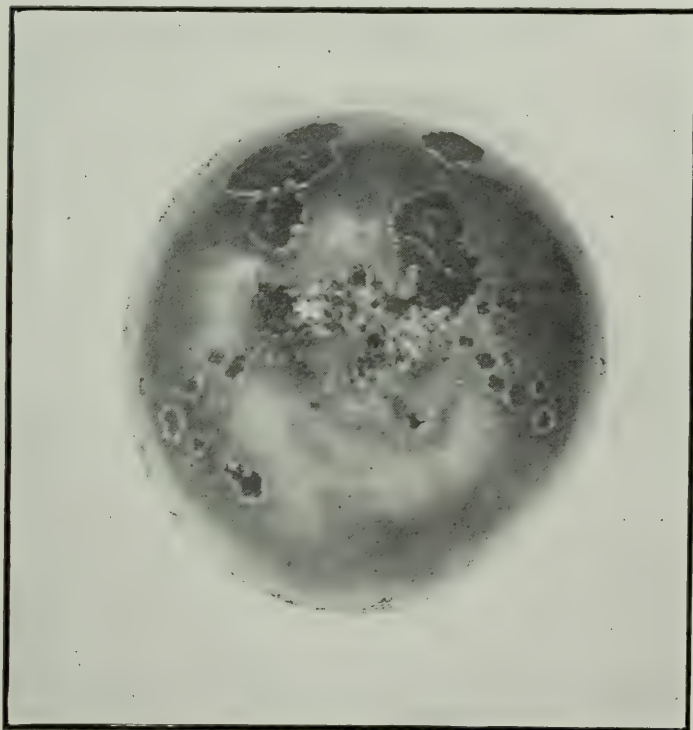


Fig. 14. Apple Scab.

PEACH SCAB.

(Cladosporium carpophilum, Thüm.)

The Peach Scab disease causes little black spots on the fruit; sometimes when it is very severe the fruit is cracked.

Treatment: By using the self-boiled lime-sulphur for the Brown Rot the Scab is also controlled. If it is desired to spray for it alone a single application of this wash applied about four weeks after the blossoms fall will be sufficient.

APPLE SCAB.

(Venturia inaequalis, (Cke.) Aderh.)

Apple Scab is the main disease in Ontario attacking the fruit of the apple. It also attacks the leaves. The disease begins to appear on the leaves about the time of the earliest blossoms, hence to control it we must spray once a little earlier than this date.

Treatment: Use either commercial lime-sulphur 1 gal. to 30 or even to 40 of water, or self-boiled lime sulphur (10, 10, 40), or Bordeaux (4, 4, 40). Spray three times, first a little after the leaf buds have opened but before the blossoms appear, second when most but not all of the blossoms have fallen, and third about three weeks later. A poison should be used with at least the first and second applications, especially with the second as this is the proper time to spray for the Codling Moth. For what poison to use see discussion under "The Use of Arsenicals with Lime-sulphur."

PEAR SCAB.

(Venturia pirina, Aderh.)

The Pear Scab is very severe on some varieties, especially Flemish Beauty. (Fig. 15.) It produces dark blotches here and there over the surface of the fruit, often causing it to crack and become quite unfit for market. The leaves are also attacked. It is more difficult to control than Apple Scab.

Treatment: Spray four times as follows: first, before the leaf buds burst; second, just after these have burst but before the flower buds have quite done so; third, as soon as most of the blossoms have fallen; and fourth, two weeks later. The application before the buds burst seems to be necessary for the control of the disease. Either home-boiled or commercial lime-sulphur may be used for the first application and commercial for the other three at about the same strength as for apple foliage. This method of treatment gave absolutely scab-free Flemish Beauty pears at Guelph this year in the writer's experiments.



Fig. 15. Pear Scab.

Bordeaux 4, 4, 40 used at the same dates has frequently given good results.

A poison should be combined as in the case of Apple Scab with the second and third applications.

BLACK ROT CANKER OF APPLE TREES.

(*Sphæroopsis malorum*, Pk.)

Much of the dying of branches and trees usually attributed to winter killing is really due to a very destructive fungus disease known as Black Rot. This disease attacks the leaves, fruit, trunk and branches of apple trees, and less frequently of pears. On the leaves it causes small circular spots about one-eighth of an inch in diameter and usually with a purplish border; on the fruit it causes a firm, not a soft, brown rot which turns black late in the season; on the trunk and branches it causes dead areas, called cankers, some of these often of large size. The disease on the leaves and fruit is seldom serious, but the cankers produced on the trunk and branches often do very great damage. The disease is worst in the counties east of Toronto, where it is a very common sight to find numerous branches or even whole trees killed by it. The fungus usually finds an entrance through some wound, such as those made by boots when climbing trees or by whiffle-trees when cultivating the orchard. It often, however, follows sunscald, and on the branches frequently begins in the cracks caused by the bursting of the bark due to the very rapid growth in spring.

As a rule the disease does not die out in these cankers at the end of the season but continues to extend in every direction year after year until at last it completely girdles the trunk or branches and kills all above the girdled area. Small superficial cankers, however, do often die out before doing much damage.

There is no disease in Eastern Ontario that requires more careful attention than this Black Rot Canker since it threatens, not the quality of the fruit, but the very life of the tree. Experiments in New York State in previous years and by several persons in our own Province this season show that we may hope for complete control by following the methods outlined below.

Treatment: Spray thoroughly with home-boiled lime-sulphur or Bordeaux mixture in spring before the buds begin to burst, taking special pains to cover the bark of the tree and branches. This is to destroy the spores which begin to spread early in the spring.

Mr. Frank Dempsey, of Albury, and Mr. Charles Dakin, of Rednersville, both in Prince Edward county, have been testing the home-boiled lime-sulphur wash this year for the control of canker, which is specially severe in that county. They report excellent results and predict that the wash will be used very extensively throughout their district next year.

The second, third and fourth spraying should be at the times indicated above for controlling Apple Scab. In these sprayings one man should always remain on the ground with a rather short extension rod, and have as his chief duty the spraying of the lower branches and trunk. Either Bordeaux mixture (4, 4, 40) or commercial lime-sulphur, about 1 to 30 or 40, may be used for these sprayings.

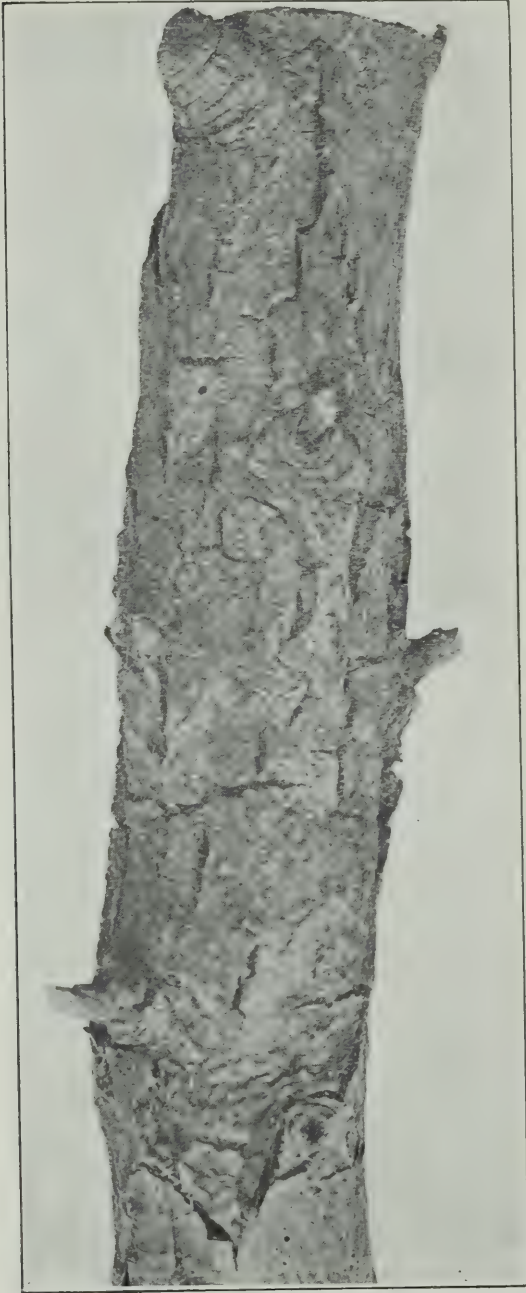


Fig. 16. Black Rot Canker on apple branch. About two-thirds natural size.

Whenever the cankers on the trunk or main branches can be cut out this should be done early in spring and the wound thus made disinfected with corrosive sublimate of the strength of 1 part by weight to 1000 parts of water, and then thoroughly painted over with white lead free from turpentine. The corrosive sublimate is very cheap and can be procured in the form of tablets, one of which is sufficient to use with a pint of water.

Caution: Corrosive sublimate is deadly poison if taken internally. It corrodes iron, so should be carried in a wooden or glass vessel and applied with a sponge or swab on the end of a stick. See that the vessel is thoroughly washed before using it for any other purpose.

In cutting out the canker the writer has found a drawknife very satisfactory. Care must be taken to cut back to the perfectly healthy bark on every side. Some have failed to do this, and consequently did not get good results.

This cutting out should be done before the spraying begins. Branches with far advanced cankers should be sawed off and burned. Scions from desirable trees may then be grafted on to take their place.

It is found that some kinds of trees are much less subject to canker than others. Pewaukee, Tolman Sweet, and McMahon White seem to be the least subject; consequently if these are planted and then top-grafted with other more desirable but less resistant varieties an excellent hardy stand of trees should be the result.

Note: Anything that tends to make trees more thrifty helps to ward off canker, hence orchards should be fertilized and cultivated up to July.

BROWN ROT OF CHERRY AND PLUM.

(*Schlerotinia fructigena* (Pers.), Schröt.)

As mentioned above this is the same disease as attacks the peach and is so well known that it needs no description.

Treatment: As the disease often attacks the blossoms the first spraying should be shortly before the buds burst with either home-boiled or commercial lime-sulphur (spring strength) or Bordeaux (4, 4, 40). The second spraying should be very soon after the blossoms fall. The third spraying should be about three weeks later. Plums may be given a fourth spraying two or three weeks after the third. For the second, third and fourth spraying use either commercial lime-sulphur 1 to 40 (if there is any sign of burning dilute still more) or self-boiled lime-sulphur (10, 10, 40) or Bordeaux mixture (2, 2, 40). With the second and third applications from 2 to 3 lbs. arsenate of lead or 1 quart of the stock solution of arsenite of lime should be used to every 40 gallon barrel of the mixture. This is to keep the Curculio in check.

In dealing with Brown Rot it is always a help to prune the trees sufficiently to let in plenty of sunlight and air, and, as said above, to destroy any mummied fruit that may be left on the trees.

CHERRY LEAF-SPOT OR SHOT-HOLE FUNGUS.

(Cylindrosporium padi, Karst.)

This disease attacks the leaves of the plum as well as cherry but is more severe on the latter. Several reports of cherry orchards almost defoliated with it have been sent to the writer from different parts of the province.

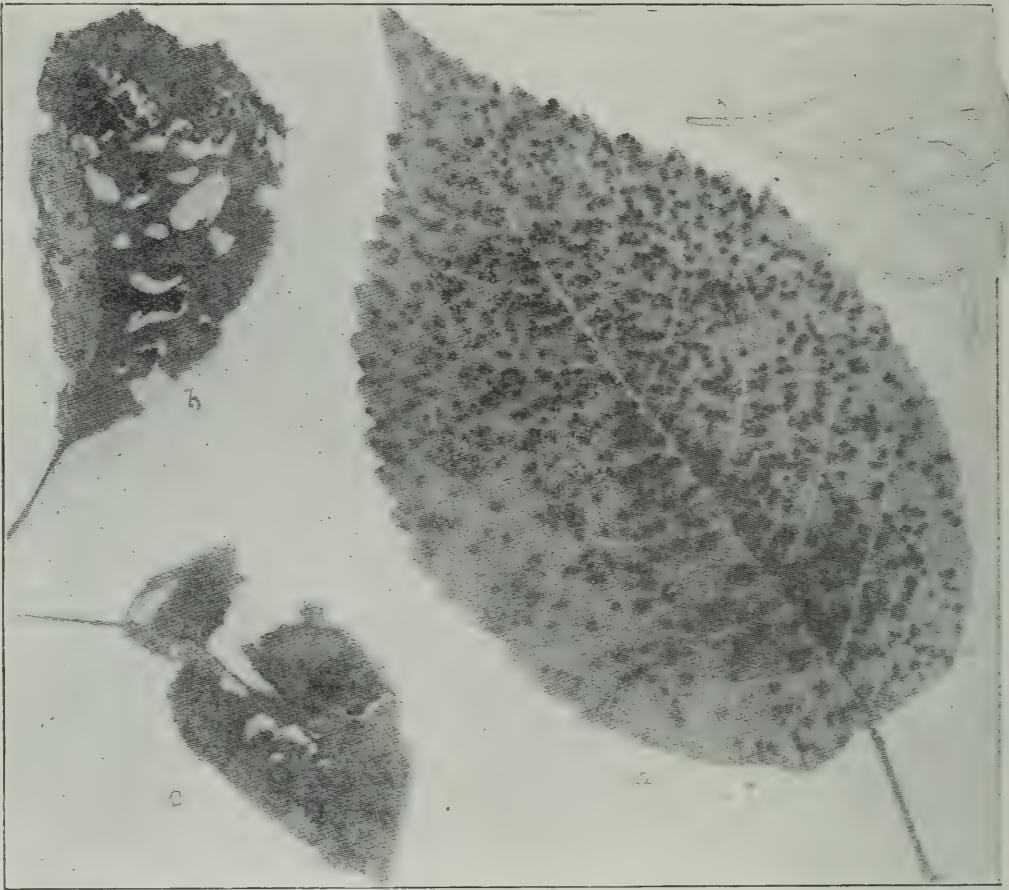


Fig. 17. Cherry Leaf-spot or Shot-hole Fungus.

Treatment: Use commercial lime-sulphur 1 to 40 or 50 or self-boiled lime-sulphur (10, 10, 40), or Bordeaux mixture (2, 2, 40) and spray first about four weeks after the blossoms fall, and second immediately after the fruit is picked; occasionally a third spraying about two weeks later may be necessary.

POWDERY MILDEW OF THE GOOSEBERRY.

(Sphaerotheca mors-uvae (Schw.) B. & C.)

Imported or English gooseberries are usually so severely attacked by the Powdery Mildew that it is seldom profitable to grow them. The disease attacks the shoots, leaves and fruit. Currants are also attacked but not so frequently nor severely. At first the disease appears as a whitish powdery covering of the affected parts but later on this develops into a thick felty brown coat that is especially noticeable on the fruit.

Treatment: Spray about the time the buds are ready to burst with home-boiled lime-sulphur, covering every part thoroughly with the wash. Commercial lime-sulphur does not seem to have been tested but would probably give the same good results. Mr. Joseph Tweddle, of Stoney Creek, Mr. E. D. Smith, of Winona, and several other fruit growers have informed the writer that the above treatment has given them excellent results, and that they highly recommend it. It is probable that a second treatment just after the fruit has set with either self-boiled or weak commercial lime-sulphur would assist in the control of the disease.

OTHER KINDS OF POWDERY MILDEW.

There are many kinds of Powdery Mildew besides the one mentioned; for instance, one kind attacks the foliage and twigs of the cherry, another attacks in a similar way the peach, another the grape. As sulphur is the standard remedy for all of these it is almost certain that lime-sulphur would be equally efficient and probably more so.

Treatment: As soon as the first sign of the disease appears spray with self-boiled lime-sulphur or the commercial wash diluted to the strength the foliage will endure. On peaches the self-boiled should be used.

The above are all the important insects and fungus diseases of Ontario for which the writer feels it safe at present to recommend lime-sulphur as a means of control. He has tested to a limited extent both the commercial and self-boiled washes on potatoes, but found Bordeaux mixture superior to either. On grapes he has been unable to test any form of lime-sulphur, but Washington reports seem to indicate that for the Black Rot of Grapes, the worst grape disease in Ontario, Bordeaux mixture is still to be preferred.

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Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE.

CHARACTER AND TREATMENT OF SWAMP OR MUCK SOILS.

BY W. P. GAMBLE AND A. E. SLATER.

Of late years considerable attention has been given to the study of swamp or muck soils, including their chemical composition, manurial treatment, reclamation and permanent improvement. In the Province of Ontario alone we have thousands of acres of such soils, many of them valueless and abandoned, others yet unreclaimed, large areas under cultivation but yielding poor crops, whilst others again are some of our richest and most productive soils. The economic importance of this question will, therefore, be clearly recognized when we remember that according to the Report of the Ontario Agricultural Commission appointed in 1881 "to enquire into the Agricultural resources of the Province of Ontario, the progress and condition of agriculture therein, and matters connected therewith," almost every township is reported to have some such land, the estimated acreage varying from a few hundred to forty thousand or more. In the aggregate, there must have been hundreds of thousands of these swamps.

Outside of Canada the great stretches of moorland in Northern Germany, the fens of Eastern England, the heaths of Scotland, the peat bogs of Ireland, the everglades of Florida, and a vast extent of territory in other States of the Union, are familiar examples.

Undoubtedly, in some instances, the owners of these lands have gone to considerable expense in draining these areas, but in many cases the results have been far from satisfactory. Indeed, in some cases the cultivation of ordinary farm crops has been abandoned, and the land allowed to remain in pasture. There is not the slightest doubt that these soils, if properly understood and cultivated, would form a valuable asset of wealth to the Province, and the object of this Bulletin is to deal with the nature of these soils and their treatment, and the subject is taken up as follows:—

First, origin, formation and composition; secondly, the application of various fertilizers, commercial and otherwise; thirdly, reclamation and

subsequent treatment by means of drainage and other mechanical means, resulting in their permanent improvement and conversion into tillable soil and, lastly, some of the causes of their unproductiveness and suggested remedies for the same.

While it will not be possible to locate and investigate, and more particularly to analyze fully, all the different areas of peaty or swamp soils throughout Ontario, until a detailed soil survey be extended throughout the Province, and soil maps be drawn out, nevertheless, we have already obtained much information of a very valuable and practical character from over nine hundred of our farmers in this Province. A circular letter was sent out to a large number, asking for particulars as to what acreage of swamp land was cultivated on their farm, the nature of the original tree growth, the length of time of cultivation, the nature of the subsoil, whether drained, and if so, how, and as to whether the yields had been satisfactory or not, and what crops appeared to do best. Replies came in rapidly, and a most valuable mass of material from some of our most successful and intelligent farmers was thus gathered together, most of the information being of a very practical character.

Reference is made to these letters throughout this Bulletin, and extracts are quoted from them, and the whole has been published because we know that this information can be used by many of our farmers with advantage and profit.

DISTRIBUTION.

Some idea of the distribution of these soils throughout the Province can be gained from noting the counties from which we have received samples of muck soils for analysis. (See Table 1.) Soil 1 came from Dundas, soils 2, 3 and 4 from Lanark, 5 from Russell, 6 from York, 7 from Kent, 8 from Hastings, 9 from Simcoe, 10 from Grey, 11 and 12 from Victoria, 13 from Carlton, 14 and 15 from Renfrew, 18, 19 and 20 from Wellington, 22 from Lambton, 23, 24 and 25 from Abitibi, 26 from Bruce, and 27 from Essex. Every one of these counties have considerable areas of swamp soil, and many other counties, the soils of which we have not examined, also contain large tracts of swamp land.

The term peat, swamp, or muck soil, is applied to a class of soils formed almost exclusively of the more or less decayed residues of vegetation, as roots, leaves, and aquatic plants, but especially mosses, particularly partially decayed sphagnum moss.

ORIGIN AND FORMATION.

Usually these swamps are formed in low-lying places where the seepage water from the surrounding land has collected, or along river banks or lake shores. The water naturally contained some plant nutrients that formed food for certain forms of plant life which could live under the prevailing conditions. The presence of water excluded

air and prevented the complete decomposition of the vegetable matter. Thus, year after year, and possibly century after century, the organic matter accumulated until it was one or many feet deep. When the surface of this accumulated organic matter rose to near the level of the surrounding land, so that the surface water drained off during the summer months, trees of various kinds capable of growth in such a soil took root and grew. Thus, cedar, tamarac, elm and ash swamps were formed. Or, according as other conditions prevailed, marshes, growing reeds and sedges of various kinds may have formed. Finally, as the land was needed for cultivation, timber and stumps have been cleared away, and the swamp soils in various stages of decomposition remain, mostly covered with a rank growth of coarse grasses and mosses, and frequently considered of little value for raising crops.

CHARACTER OF THE SOIL.

All these filled in bog or swamp areas, then, naturally contain materials rich in organic matter, and, consequently, in nitrogen. However, owing to the high acidity of the peat and bog water, poor aeration of the entire mass, and to low temperature, the action of the nitrifying germs (germs that convert organic nitrogen into soluble nitrates), is almost entirely prevented, and, as a result, very little, if any, of the large amount of nitrogen present is in a form that can be assimilated by domestic plants. This class of soils is also usually deficient in potash, although they frequently contain rather large quantities of magnesia and lime, and about the normal amount, or a little less, of phosphoric acid. On the other hand, where a certain amount of sediment from the surrounding upland mixed in with the accumulating organic matter during the filling up period, and when the temperature is more favourable, bacterial action is more active and the organic matter decays more rapidly. Such soils are naturally less acid and contain more potash than other swamp soils, and may be brought into a productive condition very much more quickly than the deposit in the deeper and colder bogs.

The peaty soil varies from almost pure brown peat, containing 80 per cent. or more of combustible matter, to black muck containing much less organic matter.

In a true swamp soil such as this Bulletin treats of, the peaty matter is frequently found throughout the Province from one to several feet deep, and in various stages of decomposition. Some of the samples of soil sent to this laboratory for analysis showed that decay had proceeded far enough to give it a good physical condition, while others consisted almost wholly of partially decayed wood and plants of such a nature that when drained it dried out too much, and, because of the coarseness of its texture, could not lift water by capillarity from the abundant supply lying immediately below.

In some cases our farmers have entertained an erroneous idea with reference as to what constitutes a swamp soil. A low-lying black soil,

two to four inches deep, does contain considerable organic matter and is rich in nitrogen, but it is usually mixed with large quantities of mineral matter, and is not of the true swamp type. Sometimes, however, when the swamp land has been under cultivation for a long time, or when the greater part of the organic matter has been burned off, the vegetable matter may not be any deeper than that mentioned above. The value of such land will depend largely upon the nature of the subsoil and the care exercised in the handling of it.

The productiveness of swamp soils appears to be more or less dependent on the nature of the tree growth. Correspondents throughout Ontario have generally agreed that where the original growth was tamarac or black spruce the soil was rather unproductive. Indeed, many farmers stated emphatically that reclaimed tamarac swamps made very poor farm lands.

The nature of the subsoil also influences productiveness. In general, when the swamp material lies over clay, it will be rich in potash, and the yields are frequently excellent. A sandy subsoil invariably yields poor results. There also seems to be a general agreement among correspondents that the deeper the black layer of organic matter the poorer the crop returns. In many cases where there is two or three feet of muck, sufficiently drained, and decomposed enough to allow of it holding moisture, the crops have been excellent for a few years. Gradually, however, the crops have become less and less satisfactory, until farmers seem to have lost hope of ever obtaining remunerative returns.

The acidity of these soils is a point worthy of note. When decomposition of soils rich in vegetable matter takes place, large quantities of various acids are formed. These must find in the soil bases with which to combine, or else the excess of unneutralized acid present will become injurious, arresting nitrification, and checking growth. The most common base with which these acids combine is lime, and soils containing a large amount of free acid are generally lacking in that constituent. It has been conclusively shown by the analysis of many swamp soils scattered throughout Ontario that usually they do not give an acid reaction, but, on the contrary, are rich in lime, the percentage of which in most cases has been much higher than that in ordinary clay loams. Out of forty-four samples analyzed, only three were found to contain less than one per cent. of lime, and none of them were noticeably sour or acid. In this respect they show a marked difference to the sour or acid swamp soils of Illinois, which are mostly deficient in lime. This point of high lime content should be borne in mind, as it influences the form in which commercial fertilizers are applied, as will be shown later.

HOW TO ASCERTAIN IF SOILS ARE OF AN ACID NATURE.

It is a simple matter for the farmer himself to find whether or not a soil has acid or sour properties. Take a narrow strip of blue litmus

paper (which may be obtained at the druggist's), about two inches long. Place a few ounces of the muck soil in a glass, and make it into a sticky mass by adding a little water and stirring. Let it stand for half an hour, and then by means of a knife separate the mass, and insert in it the strip of litmus paper, and press the moist soil against it. Allow it to remain for about five minutes. Remove the paper and see if the end placed in the soil has changed from its blue colour to red. If such a change has occurred, it proves that the soil is acid, and that liming will prove beneficial. Handle the litmus paper as little as possible, and be sure that it is distinctly blue before placed in the soil, for much handling will also redden it.

This blue litmus paper test furnishes also a good means for testing for acidity in subsoils, or soils very deficient in organic matter, where the acid substance may be largely of mineral origin. A good supplementary test, which is applicable only in soils containing a good deal of humus, is made by means of adding dilute ammonia water to soils. (Ammonia, too, can be bought from druggists at slight expense.) In making this test take two glasses, place a level tablespoonful of soil in each, then add water until the glasses are about two-thirds full.* Now add a tablespoonful of dilute ammonia water to one of the glasses. Stir each with a different spoon. If, after standing some hours, the liquid in the one to which the ammonia water was added has become dark brown or black, it may be concluded that acid humus was probably present, hence that liming will prove beneficial.

It might be stated here that the "acid test" outlined above with litmus paper will give reliable results in every case where an appreciable amount of acid is present. If, however, the soils be but slightly acid, the test may not be sufficiently delicate to indicate it.

CORRECTION FOR ACIDITY.

Soils which contain, naturally, enough lime in suitable form do not become sour, because the acid substances which are formed during the decomposition of plants unite with the lime, forming what is known as "mild humus," and when such is the case ammonia water fails to give dark or black extracts, such as are obtained with soils containing "sour humus."

Owing to the tendency of muck soils to acidity, it is important that there should be a small amount of lime (as carbonate) present in the soil. The chemical corrective for an acid is an alkali. Quick lime and slaked lime are alkaline substances, and their application is probably the cheapest, most effective, and most permanent means of correcting acidity in soils. Other alkaline substances, such as wood ashes, basic slag, etc., are also effective means of correcting acidity.

Since the simple tests for acidity in soils have been pointed out, there is no reason why anybody should cultivate acid soil without being aware of it, and without correcting the condition by liming. Let it be

further understood that the tendency to acidity which exists in the case of all soils which lack lime is much greater when certain artificial fertilizers are used than when only stable manure is employed. Bone-meal and Basic slag, gradually correct soil acidity, while the immediate effect of acid phosphate may be to make it more acid. Kainite and Muriate of potash are likely to increase the acidity of soils more rapidly than Sulphate of potash.

With this brief review of a few of the more important facts relating to acidity, it is interesting to note that practically all of the muck soils examined at this station contain fair amounts of lime. This does not, however, mean that all of the muck soils in this Province contain sufficient lime to counteract the tendency to sourness. Muck soils have come under our observation which exhibit a highly acid condition. In such cases liming should be resorted to. But, for reasons which will be explained later, the practice of applying lime to all muck soils is not in keeping with the requirements of the case.

UNPRODUCTIVENESS DUE TO ACIDITY.

It has been observed that marked and lasting improvements of soil conditions resulted from the application to acid soils of such materials only as are capable of reducing or overcoming soil acidity. While there can be no question but that these substances improve the physical properties of the soil in certain cases, and, in some instances, doubtless proved of some value as direct plant foods, the evidence that their beneficial action was chiefly by virtue of neutralizing acidity appears to be indisputable.

THE INORGANIC SOIL CONSTITUENTS.

Of these only Potash, Phosphoric Acid, and Lime, need be discussed here, together with a short note on Nitrogen.

POTASH. Potash is usually found most abundantly in clays, where it results from the decomposition of felspathic rock. In swamp soils it is liberated by the decomposition of the woody matter and peat. To the farmer, this substance is most important, since it is one of the three usually most deficient in swamp soils, and which must frequently be applied in the form of fertilizer before the soil can become productive. Potash is needed particularly by the young growing plant, as it helps to build up the tissue and to form a stiff, strong straw, less apt to lodge. Potash is taken from the soil by crops in the earlier stages of plant growth. In the case of wheat, three-quarters of the potash is taken up before the plant "heads out." Corn requires its potash chiefly during the first six weeks of its growth. Flax also makes a heavy demand on potash at an early period of its growth. Potash salts concentrate principally in the stem and straw of plants.

PHOSPHORIC ACID. All plants need an abundant supply of available phosphates at very early stages of growth. Wheat, for instance, requires about 80 per cent. of its phosphates in the first half of the growing period. Clover assimilates practically all it needs by the time it reaches full bloom. Phosphates are absolutely essential to the production of grain, and usually concentrate in the seeds of all plants. Light weight grain is often the direct result of lack of available phosphoric acid, and this would seem to be the cause of so much light grained oats, barley and wheat, being raised on our swamp soils. This whole question will be treated more fully, however, under the heading "Application of Direct Fertilizers."

LIME. Lime is also an important constituent of plant food. Directly and indirectly, lime is of great service to growing crops, and many agricultural authorities place the minimum limit in a soil for good returns at 1.0 per cent. The presence of lime favours the nitrification of humus, and also sets free inorganic elements of plant food.

NITROGEN. Nitrogen is absolutely essential to all vigorous, healthy growth. It is used by the plant principally in building up the proteids of all grains. It is also a constituent of the green colouring matter of all plants, and the yellow colour growth of so many of our cereals grown on swamp soils, is, in some cases, due to the lack of available nitrogen in these soils, in spite of the large amounts of total nitrogen which they may contain. Moreover, as in the case of potash and phosphoric acid, nitrogen is also needed by the plant in its earliest growth, soon after germination in fact, and if it be absent at this time, a subsequent later application made on the growing crop will not help it to any very great extent. In this connection it must also be remembered that climatic conditions and season influence the application of nitrogenous fertilizers to a great extent. In late, wet seasons, the production of nitrates is retarded owing to the undrained, cold nature of the soil, and an application of a quick acting fertilizer, as sodium nitrate, generally gives marked results, giving the crop the required start.

VALUE OF A CHEMICAL SOIL ANALYSIS.

Such questions as the following are, we believe, capable of being answered in this Bulletin, and we trust may prove of some value in connection with a study of swamp soils: Is this soil able to produce good crops without the aid of artificial manuring? If so, how long can constant cultivation be practised without a diminution in the yield of the crop? In what elements does it seem to be well supplied, and more particularly, in what does it seem to be deficient, and therefore, what fertilizer will yield the best results? And, lastly, what crops are best suited to these soils, and how are they apt to behave?—the latter, of course, depending largely on the nature of the season.

A considerable number of swamp soils from different places in the Province have been analyzed by this station, and they are found to be for the most part very rich in Nitrogen, a fair supply of Phosphoric

acid, rather low in some cases, but mostly deficient in Potash as compared with the ordinary fertile soils of our Province. It has long been known that such soils are frequently deficient in mineral elements, particularly in a soluble form, and the behaviour of crops on these soils bears that out.

TABLE NO. 1.—CHEMICAL ANALYSIS OF SWAMP OR MUCK SOILS.

	Moisture.	Organic and volatile matter.	Insoluble matter (sand, etc.)	Oxides of iron and aluminum (Fe_2O_3 & Al_2O_3).	Lime (CaO).	Magnesia (MgO).	Potash (K_2O).	Phosphoric acid (P_2O_5).	Nitrogen in organic matter.
	°	%		%	°	°	%		%
o. 1.....	12.68	72.10	9.45	3.75	5.25	1.06	0.13	0.15	2.64
o. 2.....	5.21	70.71	10.69	4.93	7.39	0.42	0.52	0.10	2.27
o. 3.....		60.80	23.26	5.41	6.22	0.70	0.23	0.08	2.25
o. 4.....		64.86	2.46	4.35	4.99	0.36	0.23	0.31	1.82
o. 5.....	14.28	56.41	12.03	4.55	0.49	1.49	0.42	0.02	.....
o. 6.....	12.05	57.39	21.64	9.51	3.68	2.11	0.07	0.20	2.65
o. 7.....	7.35	48.63	31.54	1.66	1.95	0.45	0.03	0.09	1.14
o. 8.....	2.74	72.58	8.13	3.17	3.18	1.53	0.40	0.16	2.59
o. 9.....	6.60	43.09	41.00	3.72	4.15	0.57	0.18	0.01	0.92
o. 10.....	8.25	89.10	2.58	2.61	1.42	0.08	0.65	0.12	1.92
o. 11.....	3.71	85.20	4.53	1.46	1.21	0.60	0.11	0.09	2.25
o. 12.....	20.12	39.44	31.01	4.02	2.75	0.45	0.07	0.29	1.16
o. 13.....	16.22	68.51	3.92	4.26	5.35	0.48	0.21	0.28	1.85
o. 14.....	10.90	75.55	3.40	3.80	4.11	0.63	0.13	0.05	2.42
o. 15.....	15.49	60.88	15.92	2.17	5.43	0.75	0.09	0.11	1.81
o. 16.....	9.54	90.15	2.16	1.75	0.95	0.01	0.06	0.19	1.63
o. 17.....	2.76	92.51	1.00	1.54	0.97	trace	0.01	0.25	2.80
o. 18*.....	11.71	53.02	21.40	0.54	5.42	0.15	0.21	0.22	1.64
o. 19*.....	11.29	52.77	27.22	1.40	3.68	0.09	0.33	traces	1.16
o. 20*.....	7.63	77.81	3.16	1.18	5.53	0.04	0.14	0.17	1.45
o. 21*.....	7.48	77.91	4.45	1.55	4.43	0.04	0.11	0.27	2.60
o. 22.....	6.1	49.9	28.8	10.91	2.86	0.71	0.09	0.14	2.88
o. 23.....	12.14	74.46	4.26	0.85	2.92	trace	0.12	0.30	1.41
o. 24.....	0.41	71.19	6.04	6.94	5.93	trace	0.20	0.29	.....
o. 25.....	14.17	74.64	3.09	0.17	2.66	trace	0.11	0.32	1.83
o. 26.....	13.01	41.63	30.74	2.86	2.88	0.65	0.33	0.29	0.47
o. 27.....	9.86	78.52	3.66	3.17	2.45	0.04	0.25	0.39	1.99

* College Farm, Wellington County.

TABLE II.—ANALYSIS OF FERTILE SOIL TYPES.

	Sandy Soil.	Sandy Loam.	Loam.	Clay Loam.	Heavy Clay.	Calcar- eous Soil.
	° C	° C	%	° C	° C	° C
Moisture						
Organic and volatile matter ...	.49	8.05	5.58	5.42	.....	6.41
Insoluble matter (sand, etc.) ...	93.14	77.59	81.42	80.76	74.40	30.04
Oxides of iron and aluminum (Fe_2O_3 & Al_2O_3)	5.80	6.75	7.28	10.00	12.02	6.55
Lime (CaO)	.21	.45	1.23	1.15	1.04	31.36
Magnesia (MgO)	.42	.31	1.02	.58	.91	2.12
Potash (K_2O)	.13	.25	.46	.68	.90	.33
Phosphoric acid (P_2O_5)	.07	.34	.36	.28	.47	.15
Undetermined.....						
Per cent. of nitrogen in soil....	.16	.18	.31	.27	.29	..

It must be stated here that although a chemical soil analysis cannot be considered to state definitely whether a soil will yield productive crops or not, yet it is a clear indication of the total amount of plant food present, and if this figure be low, then clearly the soils are deficient in certain mineral constituents (principally potash and phosphoric acid), and to yield heavy crops must be supplied with additional plant food in the form of various commercial fertilizers.

Looking at the percentage of nitrogen in these soils we find that it is very high in every case. Notwithstanding this fact, crops are often observed to be of a yellow colour and of a weak, sickly growth when grown on these soils. This condition when seen in other soils, is usually put down to a lack of nitrogen, or to the *scalding* effect of water. The same can apply here. Though the stores of total nitrogen are so great, it is locked up in an inert condition, for the fact that decay and the subsequent nitrification has not gone far enough in some cases to break down the organic or humic compounds, and to set the nitrogen free in the soluble nitrate form. One of the first requisites, therefore, is cultivation and the addition of farmyard manure to hasten these beneficial actions, and to gradually unlock the vast stores of insoluble material.

We are sometimes asked, what is the minimum amount of each of the plant constituents that must be present in a soil in order to produce good crops. In attempting to interpret the results of a detailed chemical analysis, so many other factors affect and modify conclusions that it is extremely difficult to establish a minimum standard. * Hilgard, as the result of a great deal of work on the soils of the Southern and Western States, gives the following figures, which represent the amounts of the several essential ingredients, soluble in strong

* Report of the California Agricultural Experiment Station, 1888-89, pp. 163, et seq.

hydrochloric acid, that soils of various character should contain. It may be stated here, that the amounts of plant food extracted by strong hydrochloric acid is a comparative measure of the total amount of plant food present that can be assimilated by plants, and which may in time be rendered soluble by the organic acids exuded by the roots.

TABLE III.

Potash:

In sandy soils of great depth may be less than	0.1%
In sandy loams	0.3 to 0.1%
In loams	0.45 to 0.3%
In heavy clays and clay loams	0.80 to 0.45%

Lime:

In lightest sandy soils not less than	0.1%
In clay loams not less than	0.25%
In heavy clay soils not less than	0.50%
No advantage in having more than	2.00%

Phosphoric Acid:

Seriously deficient in virgin soils when less than	0.05%
Unless accompanied by a large amount of lime.	
Sandy soils with fair supply of lime	0.1%
Sandy soils with poor supply of lime	0.2%
Clayey soils not less than	0.2%

DISCUSSION OF TABLE I.

A brief study of the above table shows us at once the striking feature of these soils as compared with an average clay loam. In the case of humus soils we have a very low figure, from 1.00 to 41.00 per cent. of insoluble inorganic residue (sand, etc.), and a very high figure, 39.44 to 92.51 per cent. of organic and volatile matter. In the case of a clay, however, the reverse is true. Here we have but 6.26 per cent. of organic matter, and 75.76 per cent. of insoluble inorganic matter (sand, etc.). This difference is easily explained when we remember the formation of these two classes of soil. The clay loam has been formed by the breaking down of feldspar rock and other mineral constituents, while the humus soil is of organic origin. It would appear from the results of Table I. that soils 3, 6, 7, 9, 12, 15, 18, 19, giving a high per cent. (all over 15 per cent.) of insoluble inorganic residue (sand etc.), contain more or less an admixture of clay, sand or the other mineral constituents, whilst soils 4, 10, 11, 13, 14, 16, 17, 20, 21, particularly, with a very low figure for inorganic insoluble residue (none mentioned being over 4.53 per cent.) are largely of pure deep-muck formation. This theory is borne out by practical observations. Soil No. 18, for instance, occurs in a low portion of a field of arable clay loam on the College farm, and frequent cultivations have resulted in a mixing somewhat of humus (muck) and clay. Soil No. 21, on the contrary, is a reclaimed swamp that is a virgin soil, showing 77.91 per cent. of volatile and but 4.45 per cent. of inorganic and non-volatile (sand, etc.)

The only point worthy of note in the quantities of lime, magnesia, aluminum, and iron contained in the various soils, is *the high lime content in every soil analyzed*. This might readily be explained in soils No. 18, 19, which were underlaid by a bed of marl, and where deep cultivation had been practised, but how are we to explain the presence of over 5 per cent. of lime in soil 20, and over 4 per cent. in soil 21, where the subsoil was one of pure sand. This high lime content of the swamp soils of Ontario seems to be one of their characteristics. For of 54 samples analyzed in this laboratory all gave a high lime content. The presence of so much lime might be due to the percolation of seepage water from higher land. In a clay loam such high lime percentages are rarely met with. When we consider the importance of lime in the



FIG. A.—Celery grown on unfertilized soil.

soil, and particularly in relation to swamp soils, the significance of this high lime content is seen. It is worthy of note that lower percentages of potash, phosphoric acid, and nitrogen are considered adequate when a high percentage of lime is present.

Coming now to the more important mineral soil constituents, namely, potash and phosphoric acid, it will be seen, that in general these soils appear to be deficient in total potash, and in very many cases in total phosphoric acid, though the latter seems to be present in greater amounts than the former. Some few soils in which the potash content is well up to the average, or even above it, may be explained by the fact that the swamp soil may be but shallow in depth and overlies a rich clay subsoil containing large amounts of potash—which, by deep and frequent cultivation has become mixed with the top soil. Mucks overlying sands are invariably deficient in potash.

BEHAVIOUR OF CROPS ON SWAMP SOILS.

It has been the general experience of our farmers in Ontario that all crops grown on swamp soils show a tendency to run to leaf and straw, and to produce a light yield of grain more or less poorly filled. The reason is evident. These soils contain a very large amount of nitrogen in the organic matter, and a relatively small amount of mineral food. Oats and rye have, however, done well, many correspondents remark, but wheat usually is a light crop. Most are agreed that it is an excellent soil for root crops of all kinds and most vegetables. Great crops of carrots and potatoes have been grown. Onions and celery seem well suited. Sugar beets have done well in many cases. As we would



FIG. B.—Celery grown on fertilized soil. KPN5. (Potash, phosphoric acid, nitrogen. Plot 5.)

naturally expect, very large yields of hay have been grown, and pastures can hardly be equalled. Red Top thrives, as it loves damp land. Corn gives large yields, and in the United States is probably grown more extensively than any other crop on muck soils. One correspondent remarks that buckwheat seeded down to clover, timothy, and meadow fescue, for a few years resulted in good yields of oats and barley later on. Another says, "it is specially adapted for hay and grass, timothy and alsike clover, yielding immense crops." Flax is grown quite extensively on these soils also, and one correspondent in Essex County remarks "that tobacco does very well." Peas in most sections seem to do very well. A farmer in Huron County remarks that on a swamp soil about 3 1-2 feet in depth and in which the subsoil was only mixed with the black top soil at the edges

of the swamp, he grew first a crop of flax three tons to the acre, and then seeded to timothy, producing two enormous crops. Rape and buckwheat both seem to do well. Millet, oats, and hay are recommended by one correspondent as the most satisfactory rotation he has



FIG. 1.—Barley on muck soil, fertilized with potash.

tried. Summing up the whole question of behaviour of crops on swamp soils, it would seem from letters received that generally these soils are too wet in spring and dry out too much in summer, the same applying to wet and dry seasons. Also, a large number of the soils seem to improve with length of cultivation, others seem to deteriorate. These questions this bulletin will endeavour to throw some light upon.

It is a matter of common experience that when these soils are reclaimed by draining and ploughing the first few crops are good. Succeeding crops are not so large, and in some cases our correspondents state it becomes difficult to grow any crop upon the soil.

These soils are also sometimes very unequal in productiveness, some areas bearing good yields, while others produce little or nothing. When corn is grown upon these lands, often there will be one or two unusually large hills surrounded on all sides by plants which are very small and yellow. In the places where crops fail to develop normally it is common to find on pulling up the plants that they have a very imperfect root system, the tips of new roots appearing brown and soft much as if they had been corroded. Farmers frequently ascribe this appearance to wire worms, and they do sometimes work in these soils, but wire worms are not responsible for the deficient root system in most cases. The unproductive soil itself consists of partially decayed organic matter which does not contain sufficient mineral matter ($K_2O + P_2O_5$) to sustain root development. In some cases, however, the lands are unproductive because of bad drainage and failure to reduce the water level to the proper point. In general, we believe that for corn culture, as well as for the growth of other crops, the permanent water level must be greatly reduced.

COMPARISON OF HUMUS SOILS WITH AVERAGE TYPES OF FERTILE SOILS.

A careful study of the figures presented in Table II. shows a wide variation between the total amounts of plant food present in the more important types of soils. This, studied together with the table III. on the minimum amount of each constituent required for profitable plant growth, affords much information of value and interest. We note the high percentage of potash (K_2O) in loam, clay loam, and heavy clay, being, respectively, .46, .68, .90 per cent., and the low per cent. in a sandy soil and sandy loam, being .13 and .25 per cent., respectively. Now look at the percentage of potash in swamp soils in Table I. The figures vary from .01 to .52 per cent. In most cases the amount lies between that found in a sandy soil and a sandy loam. Take next the figures for phosphoric acid (P_2O_5). Here we have in a loam, clay loam, and heavy clay .36, .28, and .47 per cent., respectively, and in a sandy soil and sandy loam .07 and .34, respectively. In the case of the swamp soils the figures for phosphoric acid (P_2O_5) vary from traces and .01 per cent. to .39 per cent. It will, therefore, be seen that in the case of the samples of swamp soils examined by this station, the per cent. of both potash and phosphoric acid is rather low, in many cases more or less deficient, and in some few examples is present in fairly large quantities. It cannot be assumed from these figures, however, that all our swamp areas throughout Ontario are deficient, because thousands of these have never come

under our examination, but merely, that most swamp soils that have come under our notice seem to be poorly supplied with both these constituents.

One important point, however, must not be overlooked. The finer the texture of a soil the more soluble matter it will contain. In other words, we must know the physical condition of a soil before stating certain figures as representing the minimum amount of fertilizing ingredients necessary. This must be remembered when studying the figures given in Table No. III. The reason that a fine textured soil, to be fertile, must contain more soluble plant food than a coarse textured one is probably due to the well known fact that the physical power of soils to remove dissolved material from its solutions is proportional to the surface; that is, the finer the texture of the soil the greater is its absorptive capacity. Much, therefore, depends upon how far decomposition has proceeded, and as to whether most of the coarse, woody material has been reduced to a fine condition before it can be definitely stated what amount of the essential elements, particularly potash and phosphoric acid, must be present to render these soils fertile.

One must constantly bear in mind the fact that this work, its indications and conclusions, are general in character. One cannot apply it to all cases, but the farmer must use his own judgment and apply the facts to suit his own local conditions. Above all, he must give importance to his own practical experience, and that of others.

FERTILIZERS.

For our purpose fertilizers may be divided into three classes. Indirect fertilizers, bacterial fertilizers, and direct fertilizers. Before treating of each of these let us briefly consider the application of fertilizers as a whole. We must take into consideration the character and composition of the subsoil, as this is of great importance in determining whether or not fertilizers shall be applied. If the subsoil is clay it may gradually have become very rich in plant food through seepage water which has drained down into it for centuries; if sandy, most of the fertilizing materials may be lost, as the sand has not the same power of holding and fixing fertilizing materials.

If the soil has one to three feet of very peaty material and this is underlaid with a very deep sand subsoil, or with sand resting on rock; or if the peaty soil itself is very deep, three or four feet or more, then the land will almost certainly be deficient in potash, and the chief part of the potash required to produce crops must always be applied in the form of commercial potash salts, wood ashes, or farm manure, because of the simple fact that it cannot be furnished by either the soil or subsoil in sufficient quantities to produce continuous large crops. As a rule this class of soils will not need large applications of phosphoric acid, though a small quantity applied at commencement of growth usually yields good results.

Those peaty soils from six inches to three feet deep, resting upon a clay subsoil, are, as a rule, almost invariably rich in potash, which seldom needs to be applied in such cases.

INDIRECT FERTILIZERS.

Among indirect fertilizers may be classed lime and cut straw. Lime is not a direct fertilizer in that it seldom adds any plant food to the soil that is needed, many swamp soils being already well supplied with lime. In fact, over 2 per cent. of lime is not considered to have any beneficial action, and many of our swamp soils run from 2 to 5 per cent. The only case in which lime need be applied to swamp soils is when the farmer has himself carried out the acid test which has already been described. If the soil is acid, liming is the first requisite. On some of our swamp soils the application of lime has had more or less of an injurious result—decreasing the yield. It seems to refuse to mix with the muck soil, and for as long as four years after the application the white particles of lime can still be seen on the surface. Often, injury results from the application of lime in a caustic state. When applied in this form, particular care must be exercised to avoid excessive applications, even on soils where crops requiring a relatively large amount of lime are to be grown. Air-slaked lime has been found, in some cases, to give better results than lime which has been slaked by water. In any event, it is better to make lime applications some time in advance of seeding. Autumn applications are generally to be preferred. On soils needing lime, about every four or five years would be the proper interval for applying this material. Lime should, immediately after being applied, be harrowed into the soil, otherwise it will likely cake, and this would detract from its good effects. About 1,400 pounds to one ton of quick lime per acre is sufficient. Lime also can be applied by drawing it to the field and putting it in half bushel to bushel piles about two rods apart. If now covered with moist earth and a little water added, if necessary, and allowed to stand, it will quickly slake, and can then be spread on the surface with a shovel.

APPLICATION OF CUT STRAW.

Cut straw alone has not been applied as a fertilizer to any extent in Ontario. This does not refer to the common practice of applying farm-yard manure, which will be treated of later. Cut straw, however, has been successfully applied with good results in Indiana. A layer of rather short wheat straw about three inches thick was ploughed under, and corn grown. The increase in the yield of sound corn was 20.8 bushels per acre, and of fodder corn .91 tons per acre.

F. H. King, of Wisconsin, has also observed that the application of "coarse litter, like straw, ploughed in, is often very helpful." The

beneficial action of the straw is not clearly understood, but it is believed to improve the physical texture of the soil and to admit of a better circulation of air.

BACTERIAL FERTILIZERS.

Under this heading may be placed garden loam. An application of garden loam whenever applied to swamp soils at this station, has given very marked results. Only a sprinkling over the surface is required. The purpose of adding the loam is to supply the swamp soil with certain bacterial germs known as "nitrifying organisms." These are often absent in swamp soils, but very abundant in a garden loam or good field clay loam. They help to decompose the organic matter in the soil and



FIG. 2.—The muck soil in pot 12 was inoculated with garden loam.
Pot 1 untreated. Crop, oats.

to break up the insoluble compounds of nitrogen, converting them into such a form that they can be used by plants. The potash and phosphoric acid is at the same time rendered more available. Soils inoculated with garden loam produce crops that stand up better, usually have a stronger straw, and are more vigorous. The accompanying photograph shows this clearly.

Pot No. 1 is untreated. Pot No. 2 had an application of loam. The crop grown was oats. It would be an easy matter for the farmer to apply one load of garden loam per acre, spreading the same over the surface, and we believe the results obtained will warrant the expenditure of the labour in nearly all cases. The application may not, however, have any effect, or be unnoticeable on muck soils that have been cultivated for a number of years, or that have had an intermixture of subsoil with surface soil. In this case, these soils have already probably been inoculated,

and therefore are capable of yielding good crops. But in the case of a reclaimed swamp growing its first crop the effect of the loam is very noticeable.

DIRECT FERTILIZERS.

In this class may be placed farmyard manure—a general fertilizer; dried blood, tankage and nitrate of soda as nitrogenous fertilizers; Kainite, Potassium sulphate, Muriate of potash, and wood ashes, as Potassic fertilizers; and Thomas phosphate or Basic slag, ground rock phosphate (floats), Superphosphate and Bone Meal, form the chief source of supply of phosphoric acid.



FIG. 3.—Muck soil in pot 13 was treated with farmyard manure.
Pot B untreated. Crop oats.

APPLICATION OF FARMYARD MANURE.

Farmyard manure has been found in nearly all cases to greatly improve even the best of these lands, enabling them to give large yields. Liquid farmyard manure, however, has not been found to have an appreciable influence on the yield. This would lead us to suppose that it is the coarse litter and the straw present in the manure that is beneficial, rather than the fertilizing ingredients themselves, for the urine itself contains the greater quantity of potash, though nearly all the Phosphoric acid and the greater part of the lime is found in the solid excrement. A good dressing of farmyard manure may materially increase the yield for four consecutive years; as a rule the effect of applying potash is seen only the first and second year. An experiment to

compare the relative value of manure and blood with that of potassium sulphate was carried on at Wisconsin, with the following results. When the data are expressed as percentage of increase due to each fertilizer, it stands as follows:

Potassium sulphate	34.4 per cent.
Dried blood	20.1 per cent.
Farmyard manure	29.2 per cent.

Thus it is seen that farmyard manure and dried blood have their part in being good fertilizing materials to apply to swamp soils. The addition in every case seems to cause the greatest luxuriance of growth and earlier maturity, but with a tendency to lodge. Fig. 3 illustrates the result of the application of farmyard manure.

The good results obtained from its addition on swamp soils have been noticed by many experimenters, but wherein its great value lies is not fully understood. The reason soils so rich in organic matter and nitrogen should respond readily to the application of these slow acting organic manures is probably due to the fact that nitrifying organisms (germs) are supplied by the manure in large quantities, exactly the same as in the case of the garden loam, and these break down the organic matter, forming nitrates and releasing carbon dioxide gas, which in contact with water dissolves large quantities of mineral constituents (potash and phosphates).

APPLICATION OF POTASH.

Potash has invariably given good results. Besides the actual percentage of potash being low, the very high percentage of nitrogen causes an unbalanced condition of the soil, and potash, and frequently phosphoric acid, have both to be added to restore equilibrium, and to introduce the materials necessary for the filling of the grain.

The results of the application of potash salts, obtained from experiments conducted both at this station and throughout the Province by means of co-operative work, are placed in tabulated form, and given later.

Let us first briefly review the work done by other stations on swamp soils, and see how far it coincides favourably with our own results.

WORK OF OTHER STATIONS.

As a result of experiments with potash at Indiana, it was found that the best yield was obtained from the use of Kainite applied at the rate of 100 pounds per acre, which gave an increased yield of 27.2 bushels of corn and 1.04 tons of fodder corn per acre. Here we have clear evidence of the good results obtained by the application of Kainite.

In regard to the application of potassic fertilizers, F. H. King,

of Wisconsin, writes: "Potassium carbonate, Potassium sulphate, Potassium nitrate, and wood ashes, have all been found to greatly improve these lands for corn. Kainite also improves the yield, but to a less extent. Potassium chloride in half the quantity of the other salts killed the corn." As a result of experiments along these lines, he states as follows:

Potassium sulphate increased the stalks 2.042 times, and the ears 4.434.

Potassium chloride increased the stalks 1.893 times, and the ears 3.661.

Potassium magnesium carbonate increased the stalks 1.842 times, and the ears 3.045.

Kainite increased the stalks 1.814 times, and the ears 2.519.

Here it will be seen that the potassium sulphate gave the best results. At Michigan, the application of wood ashes, barnyard manure, and upland soil, have given the best results.

METHOD OF APPLYING POTASH.

Potash may be applied in the fall or spring, but preferably, at least one or two weeks before the crop is sown. It should be applied broadcast or in narrow drills as a general rule. All potassic fertilizers may be applied easily and quickly by hand, scattering it from the waggon. It is good practice to apply the potash after ploughing, and then to mix it with the soil by disking, harrowing, etc., in the usual preparation of the seed bed. It should not be applied when the ground is frozen over if there is likely to be any outflow or surface drainage before the potassium salt dissolves and soaks into the soil.

PHOSPHATIC FERTILIZERS.

Some swamp soils appear to be well supplied with phosphoric acid, in others it is low, particularly the soluble phosphoric acid which is frequently present in mere traces. Generally speaking, phosphatic fertilizers are not needed as much as potassic, but, in our co-operative experimental work, some excellent results have been obtained by its application. Not only does it cause an earlier maturity, but strengthening of the straw often results and a fuller, plumper grain, with an increased yield. It has generally been advocated that phosphates should be applied to swamp soils in an insoluble form, such as ground rock phosphate, or Thomas phosphate also called Basic slag. These materials are, of course, much cheaper than the more expensive chemically prepared superphosphate. They are also much slower in their action, owing to their insoluble form and also to the more or less coarse nature of the substance. Superphosphate, on the other hand, contains a large proportion of its phosphoric acid in the water soluble condition, which can be immediately used by the plant. Its action is, therefore, very much quicker.

It has been argued that if phosphates be applied as ground rock and Basic slag, then the acids that are present in muck soils will dissolve it in time, and render it available to the plant. Also, that superphosphate is itself acid in nature and, therefore, should not be applied to soils which in themselves are apt to be sour, thus increasing the total acidity. But our analyses show that our swamp soils are not *generally* acid, and therefore that the non-application of superphosphate for that reason does not follow. Some interesting results in fact will be found in the tables on co-operative work, showing that in some cases superphosphate has given very marked results. This is owing no doubt, as has been stated, to the lack of soluble or available Phosphoric acid in swamp soils and, therefore, the need of a dressing of phosphatic manure in a form readily accessible to the plant in its earliest stages of growth, just when it stands most in need of plant food. It stimulates the early development of the young seedlings to a remarkable extent, and gives them a good start; indeed, it is often used merely to secure a better plant, though with little expectation of otherwise increasing the yield. It must be remembered in this connection, that the crops most benefited by phosphatic manuring are turnips and barley, wheat responding very little, and mangels hardly at all.

When ground rock phosphate is used it must be seen to that it is sufficiently fine, as many coarsely ground and inferior brands are on the market. Its value depends largely on its fineness. To soils which are acid it certainly seems the cheapest and best form in which to add phosphoric acid to the soil.

RESULTS OF FERTILIZER EXPERIMENTS ON MUCK SOILS.

Oats in 1904.	Fertilizers per acre.	Yield per acre.
	lbs.	Bush.
1. No fertilizer .....	.....	23.7
2. Muriate of potash	200	39.0
3. Muriate of potash.....	200)	43.1
Thomas phosphate.....	400)	
<i>Experiments with Lime Included.</i>		
1. No fertilizer .....	.....	19.0
2. Lime.....	2,400	19.6
3. Muriate of potash.....	200	35.8
4. Muriate of potash.....	200)	36.7
Thomas phosphate.....	400)	
Oats in 1905.		
1. No fertilizer .....	.....	28.5
2. Muriate of potash.....	200	41.2
3. Muriate of potash.....	200)	44.1
Thomas phosphate.....	400)	

RESULTS OF FERTILIZER EXPERIMENTS ON MUCK SOILS.—*Continued.*

Corn in 1905.		Fertilizers per acre.	Yield per acre.
		lbs.	*lbs.
1. No fertilizer			2,652
2. Muriate of potash.....		200	3,380
3. Muriate of potash.....		200	3,732
Thomas phosphate.....		400	
Oats in 1906.			
			Bush.
1. No fertilizer			24 6
2. Muriate of potash.....		200	38.1
3. Muriate of potash.....		200	51.8
Thomas phosphate.....		400	
4. Thomas phosphate.....		600	29.0
Barley in 1906.			
1. No fertilizer			39.8
2. Muriate of potash.....		160	51.0
3. Muriate of potash.....		160	51.2
Superphosphate.....		320	
Oats in 1907.			
1. No fertilizer.....			22.6
2. Muriate of potash.....		200	30.7
Lime.....		2,400	
3. Muriate of potash.....		200	30.3
Lime.....		2,400	
Thomas phosphate.....		400	
4. Lime.....		2,400	26.2
Potatoes in 1907.			
1. No fertilizer			89 2
2. Lime.....		1,400	142.7
3. Lime.....		1,400	196.0
Sulphate of potash.....		200	
Thomas phosphate.....		400	
4. Lime.....		1,400	166.6
Sulphate of potash.....		400	
Oats in 1908.			
1. No fertilizer			4.5
2. Lime.....		2,400	30.5
3. Lime.....		2,400	37.0
Muriate of potash.....		200	
4. Lime.....		2,400	40.0
Muriate of potash.....		200	
Thomas phosphate.....		400	

* Shelled corn.

RESULTS OF FERTILIZER EXPERIMENTS ON MUCK SOILS—*Continued.*

Corn in 1908.		Fertilizers per acre.	Yield per acre.
		lbs.	*lbs.
1.	No fertilizer		2,840
2.	Lime.....	2,400	2,840
3.	Lime.....	2,400	4,180
	Muriate of potash.....	200	
4.	Lime.....	2,400	3,580
	Muriate of potash.....	200	
	Superphosphate.....	400	
Potatoes in 1908.			
			Bush.
■	No fertilizer		120
	Lime.....	1,400	116.6
■	Lime.....	1,400	145.4
	Sulphate of potash.....	200	
	Sulphate of potash.....	200	196 0
†	Thomas phosphate.....	450	
Shelled.			

Shelled.

DISCUSSION OF CO-OPERATIVE FERTILIZER EXPERIMENTS ON MUCK SOILS AT THIS STATION.

A careful study of the above table shows some very marked results from the application of fertilizers on swamp soils at this station.

The soil on which experiments were conducted in 1904 with Oats was a deep muck soil, which had been worked for about 15 years. The subsoil was calcareous. The application of Muriate of potash and Thomas phosphate on Plot 3 at the rate of 200 pounds of the former and 400 pounds of the latter per acre, increased the yield by 19.4 bushels. Muriate of potash alone on Plot 2 gave an increase of 15.3 bushels. It is interesting to note that lime applied with the Muriate of potash, and with the Muriate of potash and Thomas phosphate combined, *lessened* the yield, though lime alone increased it .6 bushels per acre.

The experiments with Oats in 1905 were conducted on a swamp soil which contained material fairly well rotted, but which did not produce good crops. In this experiment very marked results were obtained, though not quite so evident as in 1904. Muriate of potash and Thomas phosphate increased the yield in this case 15.6 bushels per acre, while Muriate of potash alone increased it 12.7 bushels per acre.

The effect on Corn was also very marked. Here the unfertilized plot yielded 2,652 lbs. of threshed corn. A mixture of Muriate of potash and Thomas phosphate increased the yield on Plot 3 by 1,080 lbs., while the Muriate of potash alone on Plot 2 gave an increase of 728 lbs. per acre. The soil in this case was a deep muck with a sandy loam subsoil, which explains the excellent results obtained by the addition of Potash.

In 1906, 1907, 1908 and 1909 the experiments were all conducted on typical swamp soils, varying from about two feet deep to as much as fifteen feet or more, and the soils were as uniform as possible. In some cases excessively wet seasons flooded out the plots and destroyed the experiment, but the results of those in which this did not occur are given below, and speak for themselves.

In 1906 experiments were conducted on Oats and Barley. A very marked increase is seen in the case of Oats on Plot No. 3, treated with a mixture of Muriate of potash and Thomas phosphate, which gave an increase of 27.2 bushels per acre. But Thomas phosphate applied alone gave an increase of only 4.4 bushels, clearly indicating that Potash was the ingredient needed in this case. Potash alone increased the



FIG 4.—Corn grown on unfertilized soil, and with Phosphoric acid and Nitrogen, and with a complete fertilizer.

yield 13.5 bushels per acre. From this it will be seen that frequently the application of a mixture gives distinctly larger yields than the application of one ingredient alone.

With Barley the applications did not appear to have so much effect that year. Muriate of potash increased the yield only 11.2 bushels per acre. The further application of 320 lbs. of Superphosphate only gave an additional increase of .2 bushels.

In 1907 Oats and Potatoes were experimented on; the application of Muriate of potash together with lime on Plot No. 2 gave an increase of 8.0 bushels, while on Plot No. 3, to which 400 lbs. of Thomas phosphate was applied in addition to the lime and potash, the yield was only increased 3.6 bushels. This shows that potash was needed, whereas the Phosphoric acid in this particular case gave no result.

The potatoes responded most readily to a compound fertilizer also,

i.e., Sulphate of potash 200 lbs. and Thomas phosphate 400 lbs., together with 1,400 lbs. of lime, the increase in yield being 106.8 bushels per acre. Sulphate of potash and lime increased the yield 77.4 bushels per acre. Lime alone also increased the yield 53.5 bushels, but in this connection it must be stated that the addition of lime resulted in scabby potatoes. Therefore, if lime has to be applied to correct acidity in certain cases, it should be applied to a previous crop.

In 1908 experiments were conducted with Oats, Corn and Potatoes. Better results were obtained this year than in any preceding one. The unfertilized plot in the case of oats yielded but 4.5 bushels per acre. Lime here gave a very marked increase of 26 bushels per acre. The soil experimented on was of an acid character, badly in need of liming. Lime and Muriate of potash increased the yield 32.5 bushels per acre.



Fig. 5—Experimental plots on P. S. McLaren's farm, Perth, Ontario.

whilst a mixture of lime, Muriate of potash and Thomas phosphate gave an increased yield of 36.5 bushels per acre.

Corn gave the best results of all, under an application of Muriate of potash, the yield being increased by 1,340 pounds of husked corn per acre. Lime had no effect at all, and the application of potash and Superphosphate applied together gave an increased yield of 740 pounds per acre. In this case potash was the element needed more than any other.

Potatoes again responded readily to an application of Sulphate of potash by an increased yield of 25.4 bushels per acre, and by an increase of 76 bushels an acre to an application of Sulphate of potash and Thomas phosphate combined. Lime in this case decreased the yield. It will be seen, therefore, that, generally speaking, the potato crop responds readily to a liberal application of a compound fertilizer. In general it may be preferable to use Superphosphate instead of Basic slag on soils which are rich in lime.

RESULTS OF EXPERIMENTS ON MUCK SOILS IN 1909.

Conducted by R. S. Hamer, District Representative, Department of Agriculture,
Perth, Ontario.

Oats.	Fertilizers per acre.	Weight when hauled in. per acre.
	lbs.	Tons.
1. No fertilizer.....		1.1
2. Muriate of potash.....	120	3.1
Superphosphate.....	360	
Nitrate of soda.....	120	
3. Superphosphate.....	360	2.6
Nitrate of soda.....	120	
4. Superphosphate.....	360	2.8
Muriate of potash.....	120	
5. Muriate of potash.....	120	2.3
6. Superphosphate.....	360	2.2
7. Barnyard manure.....	20 tons	2.3
NOTE.—These plots were not threshed on account of being too badly lodged in some cases to make clean threshing possible.		
	lbs.	Bush.
8. No fertilizer.....		16.4
9. Muriate of potash.....	120	25 0
10. Muriate of potash.....	120	28.23
Basic slag, '08.....	360	
11. Muriate of potash, '08.....	120	28.23
12. Muriate of potash.....	120	23.5
Superphosphate, '09.....	360	
13. Muriate of potash, refertilized.....	120	29.5
14. Muriate of potash.....	120	37.6
Superphosphate, refertilized.....	360	
Rape.	lbs.	Tons.
1. No fertilizer.....		4.4
2. Muriate of potash.....	120	11.8
Superphosphate.....	360	
Nitrate of soda.....	120	
3. Superphosphate.....	360	9.4
Nitrate of Soda.....	120	
4. Superphosphate.....	360	9.6
Muriate of potash.....	120	
5. Muriate of potash.....	120	5.2
6. Superphosphate.....	360	8.6
7. Barnyard manure.....	20 tons.	11.2
	lbs.	
8. No fertilizer.....		2.8
9. Muriate of potash.....	160	2.4
Superphosphate, '08.....	360	
10. Muriate of potash.....	160	6.0
Superphosphate, refertilized.....	360	
11. Muriate of potash.....	160	9.4
Superphosphate, '09.....	360	
12. Muriate of potash alone, '09.....	160	2 8

RESULTS OF EXPERIMENTS ON MUCK SOILS IN 1909.—*Continued.*

Millet.	Fertilizers. per acre.	Tons per acre.
	lbs.	Tons.
1. No fertilizer.....		2.8
2. Muriate of potash.....	120	7.6
Superphosphate.....	360	
Nitrate of soda.....	120	
3. Superphosphate.....	360	4.0
Nitrate of soda.....	120	
4. Superphosphate.....	360	6.08
Muriate of potash.....	120	
5. Muriate of potash.....	120	3.24
6. Superphosphate.....	360	4.04
7. Barnyard manure.....	20 tons	6.12
8. No fertilizer.....		3.0
9. Muriate of potash.....	120	3.2
Superphosphate, '08.....	360	
10. Muriate of potash.....	120	5.8
Superphosphate, refertilize.....	360	
11. Muriate of potash.....	120	5.24
Superphosphate, '09 (1).....	360	
12. Muriate of potash.....	120	3.6
Superphosphate, '09 (2).....	360	
13. Muriate of potash alone, '0.....	120	3.4
14. Muriate of potash alone, '09.....	120	2.8
Mangels.		
	lbs.	Tons
1. No fertilizer.....		4.9
2. Muriate of potash.....	120	16.4
Superphosphate.....	360	
Nitrate of soda.....	120	
3. Superphosphate.....	360	12.1
Nitrate of soda.....	120	
4. Superphosphate.....	360	15.6
Muriate of potash.....	120	
5. Muriate of potash.....	120	15.3
6. Superphosphate.....	360	13.9
7. Garden Loam.....		17.0
8. No fertilizer.....		2.9
9. Basic slag, '08.....	360	3.3
10. Basic slag, refertilized.....	360	4.8
11. Basic slag, '09.....	360	7.5
12. Basic slag.....	360	4.7
Muriate of potash, '08.....	120	
13. Basic slag.....	360	8.8
Muriate of potash, refertilized.....	120	
14. Basic slag.....	360	10.1
Muriate of potash, '09.....	120	

Co-operative experiments were conducted in 1909 with oats, rape, millet, and mangels, the results of which have been presented in tabular form. It will be noticed that the plan of the experiments in 1909 was as follows: With Oats, Rape, Millet, and Mangels, a series of plots numbered from 1 to 7; further, a second experiment with plots numbered from 8 to 14 with Oats, 8 to 12 with Rape, 8 to 14 with Millet, and 8 to 14 with Mangels. The purpose of this second series of experiments was to compare in the case of oats the results obtained on an unfertilized soil with soil fertilized with potash in 1908, in 1909, and in



FIG. 6.—Oats on Plot No. 1, unfertilized.

both 1908 and 1909; and with soil fertilized with a mixture of Muriate of potash and Superphosphate in 1908, in 1909, and in both 1908 and 1909—all worked out in duplicate. In the case of Rape and Millet, the results obtained on an unfertilized soil are compared with those on a soil fertilized with Muriate of potash and Superphosphate in 1908, in 1909, and in both 1908 and 1909. In the case of Mangels, a comparison of unfertilized soil with soil fertilized with Basic slag in 1908, in 1909, and in both 1908 and 1909; and with soil fertilized with Muriate of potash and Basic slag mixed, in 1908, in 1909, and in both 1908 and 1909.

Let us consider the experiment with Oats first. The results ob-

tained on the first series of plots, No. 1-7, are omitted, because the grain was not threshed on account of being too badly lodged in some cases to make clean threshing possible with a flail, but the cut here given illustrates clearly and in a most emphatic manner the beneficial results of fertilizers on the oat plots. On the succeeding plots, Nos. 8 to 14, some excellent results were obtained. Early Daubeney Oats were sown at the rate of 2 bushels per acre. The unfertilized plot, No. 8, showed a weak, short straw, about 65 per cent. of the grain lodging flat. The grain was light and poorly filled.



FIG. 7.—Oats on Plot No. 4, fertilized with Potash and Phosphoric acid.

Plot No. 9, fertilized with Muriate of potash alone in 1908, gave a thinner stand and shorter straw than the next plot, No. 10. The heads were not as well filled, the yield, however, being 25 bushels per acre, an increase of 8.6 bushels over the unfertilized.

Plot No. 10, fertilized with both Muriate of potash and Basic slag in 1908, gave a good, tall, heavy stand, with not much tendency to lodge. The heads were well filled and matured, and the grain hard. The yield was 28.23 bushels per acre, thus showing an increase of 3.23 bushels over the application of potash alone.

Plot No. 11, fertilized with Muriate of potash alone, in 1909 gave a better crop than the one fertilized with potash in 1908, but not as

good as the plot refertilized with potash (No. 13). Plot No. 12, fertilized with a mixture of Muriate of potash and Superphosphate in 1909, while giving a slightly lesser yield than the last plot, gave a better crop than the preceding in height and stand, of a fine healthy colour, and with practically no rust. It was evenly matured, and heads were filled with good plump grain.

Plot No. 13, refertilized with Muriate of potash, gave a heavy



FIG. 8.—Specimens of Rape grown on unfertilized and fertilized muck soil.

yield, 29.5 bushels per acre, and a much stronger stand than the potash in 1908. Some lodged grain.

Plot No. 14, refertilized with a mixture of Muriate of potash and Superphosphate, yielded splendid results, giving 37.6 bushels per acre, an increase of 21.2 bushels per acre. There was a fine strong stand, tall and well advanced, not much lodged. The heads were the best filled of any.

Some interesting results were experienced with Millet and Rape. The soil was a muck, averaging from 18 to 24 inches in depth, the last

6 inches being chiefly decayed vegetable matter. The subsoil was white sand.

Owing to the fact that even under the best conditions it is ordinarily impossible to get on this particular area much before June, it was considered advisable to experiment entirely with forage crops whose habit of growth adapted them to late seeding. Accordingly, rape and millet were used.

Both the Rape and Millet on the unfertilized plots gave poor results. The growth was thin and short. The best results were obtained in both Rape and Millet on Plot 2, with the addition of a complete fer-



FIG. 9.—Showing Mangels grown on unfertilized swamp land.

tilizer. The growth was strong and uniform and the colour good, and the yield was more than doubled.

The Superphosphate and Nitrate of soda combined (Plot 3), also did well in both cases, particularly the rape.

Muriate of potash alone with both Rape and Millet gave results lower than those obtained by the mixture. This would seem to indicate the lack of Phosphoric acid in these soils, a point which has been frequently referred to. Both Rape and Millet were a thin, short crop all summer, but distinctly better than the unfertilized plot. The result is borne out in Plots 12, 13, 14.

It will be noticed that Superphosphate alone gave better results

than potash alone, particularly in the case of rape, but poorer results than a mixture of both Superphosphate and Potash.

Attention must be drawn to the good results obtained from an application of farmyard manure (Plot 7), in both cases, the results being a little lower than those obtained from the complete fertilizer (Plot 2).

The results from refertilizing with both Potash and Superphosphate are not so marked in the case of rape and millet as they were in the case of oats.

Lastly, the results with Mangels in 1909. The soil experimented



FIG.10.—Showing Mangels grown on fertilized muck soil. (Complete mineral fertilizer.)

on was a good quality of muck—cleared from a hardwood swamp. The area has been under crop for several years, and the muck was worked down to within eight or ten inches to the clay subsoil. Owing to lack of complete drainage, it is ordinarily not sowed until late in May or the first week in June. Of late years roots have been grown, but the muck has not been manured for several years. Fair crops have resulted, except in years which were very dry during the early part of the season.

It will be noticed in this experiment that high yields were obtained at the end of each area. These high yields possibly cannot be attributed to the influence of the fertilizer alone. It will be noticed that the highest yield of all is obtained on the end plot, No. 7, to which nothing was

added but garden loam. Whether the ploughing in the spring had any influence at this end we are not prepared to say, but the fact that the clay comes nearer to the surface would undoubtedly make some difference—a favourable difference. The beneficial effect, however, of garden loam applied alone, due to its inoculating property, has already been fully discussed in this Bulletin.

It will be noticed that the unfertilized plots in both series (Nos. 1 and 8), gave very poor results, 4.9 tons and 2.9 tons to the acre. The best results were obtained from the complete fertilizer (Plot No. 2), which yielded 16.4 tons to the acre—an increase of 11.5 tons. Muriate of potash alone, and Basic slag alone, with Mangels, both gave good results, 15.3 and 13.9 tons per acre. This may be explained by the fact that the subsoil in this case was of clay, and therefore would be likely



FIG. 11.—Showing effect of Potash and Phosphoric acid on Turnips grown on muck soil.

to contain a fair amount of both these ingredients. The mixture of both, however, on Plot 4, gave an increased yield of 1.2 tons per acre more.

In the second series, Plot No. 14, a mixture of Basic slag and Muriate of potash gave an increased yield of 7.2 tons per acre over the unfertilized Plot No. 8—a very marked result.

Altogether, the results of 1909 would seem to clearly indicate the benefits to be gained from an application of a complete mineral fertilizer to swamp soils, no matter what the crop may be. Farmyard manure also generally gives as good, if not better results. The benefit to be derived from the addition of Sodium Nitrate to a mixture of Potash and Superphosphate would seem to lie in the fact that in these soils, notwithstanding the fact that they have an abundant supply of nitrogen in combination, as organic matter, it is largely a reserve stock and unavail-

able to the plant, which, therefore, readily responds to an application of nitrogen in a readily soluble form, as in Sodium Nitrate.

IMPROVEMENT AND RECLAMATION.

Before discussing the improvement of these soils, it is as well to classify them briefly. In general, they may be placed in one of four classes.

1. Soils in which the muck deposit is very deep, often extending several feet.
2. Soils in which the muck varies from a few inches to about one foot, and with an underlying clay subsoil.
3. Soils in which the subsoil is of sand, or quicksand.
4. Soils which are underlaid by a deposit of marl.

The question as to whether these soils should be tile drained or not, as to whether they should be devoted to the growing of cultivated crops, or whether it is more desirable to permanently pasture them, will depend to a great extent in which of the above classes the soil falls.

TEMPORARY IMPROVEMENT.

In cases where the heavy expense of complete drainage is not considered desirable, the question is often asked can we cause the temporary improvement of these soils by any means—by methods that are easily applied and that will prove profitable from a commercial standpoint. It has been found that an application of straw has much increased the yield, and if, at the same time, Kainite or a Potash salt be applied to supply available potash, much may be done towards temporary improvement.

PERMANENT IMPROVEMENT.

In order that a permanent improvement may be successfully brought about, the physical reasons why swamp soils are unproductive must first be clearly understood. It is caused principally by bad water conditions, the permanent water level being too near the surface. Before any special method of drainage is decided upon, it will always be both desirable and profitable to make a preliminary drainage survey of the land in question, in order to determine its present water level and the depth below the surface of the real water bearing layer. With these facts in mind, the most economical method of reducing the water level can be determined. A system of drainage which taps the water bearing subsoil underlying the humus soil, and lowers the water level to at least 40 inches, by removing the cause of unproductiveness, insures permanent improvement in many cases. In all ordinary cases the removal can best be accomplished by either tile or open drains, and attention to

drainage should always be the first step in the reclamation of these lands. Frequently when the swamp is under water and being reclaimed for the first time, and there is an abundance of surface water to be run off, open ditches often are the most rapid and effective. Once this is effected, the permanent lowering of the water table can be proceeded with. For corn growing it should be lowered to about 42 inches. With a permanent water table of 30 inches, it is certain very little corn can be raised, while with a permanent level of 42 inches first-class crops have been grown on these soils.

In raw muck lands the water will not readily enter a tile, as the pores become clogged. The water level is maintained by some source of water in the higher adjacent land and reaches the muck through a water bearing sand, gravel, clay or marl subsoil, below the muck. The water moves very readily through this, and if a portion of the tile passes through this layer the water level will be reduced to the level of the tile. If this can be done at a reasonable cost, it is generally the simplest and most satisfactory plan. It is of little use, therefore, to attempt to tile drain large areas in which the muck is several feet deep. Such lands had better be permanently pastured, or the muck dug out, allowed to dry, and then used as an absorbent in stables or applied to the land as a manure. Before drainage it is as well in all cases to make a preliminary drainage survey, which consists chiefly in digging a number of post holes in the muck to ascertain the character of the layers below the surface and, more important still, to learn the depth of the subsoil. These holes should be left open for a few days to allow the water to reach its permanent level.

For fairly deep lands, the holes may be bored with a two inch auger welded to a piece of $\frac{3}{4}$ inch gas pipe, with a T screwed on the top to hold the crosshandle. The auger and the pipe used may conveniently be about seven feet long, if needed.

The distance from the surface to the subsoil often varies several feet in different portions of the field, and from the conclusions drawn from such a preliminary survey it is often possible to reduce the permanent water level, and to, therefore, make the whole field productive, by laying short lines of tile where needed in the water bearing subsoil instead of putting in long lines of tile in the raw muck, where they will inevitably become clogged and do no good. It has even been found that tile laid about $3\frac{1}{2}$ feet deep in raw muck is quite ineffective, for the reasons stated.

"In cases where the muck is but 18 inches deep or so, a different problem from the above is presented. In this case the surface water from the land about them flows into these low places. This surface water simply needs to be kept out. The ordinary tile layer simply runs the tile through the centre of these spots, and of course fails to reduce the water level below the level of this tile, which is generally too near the surface in these low places, although it may be $2\frac{1}{2}$ to 4 feet deep in the higher portion of the field. The simplest way to keep out the sur-

face water from the surrounding land is to divide the tile line at the edge of the spot and send a line around on each side, uniting the lines again when beyond the spot. This permits the tile to pick up the drainage water from the surrounding land before it gets to the low places. A number of farmers who have tried this simple and inexpensive method have reported it very effective in changing barren, unproductive spots into the most productive portions of the field." The above method has been taken from Mr. Huston's Bulletin on "Unproductive Black Soils."

The drainage is best accomplished at first by means of open ditches at frequent intervals. Muck soils settle greatly when drained, and if tiles are laid in the soft muck they will rise towards the surface, and thus become ineffective. Drainage is most effective when carried out gradually, and the soil should not be allowed to dry out too quickly, since its mechanical condition may thus be injuriously affected, its absorptive power for water in many cases almost completely destroyed, and the decomposition of the organic matter greatly retarded. After the soil has become firm, tiles may be laid, especially if collars are used.

As to whether it is advisable to tile drain will depend on the nature of the subsoil. If it be a stiff hard pan, extremely difficult to work and break up, little will be gained by tile drainage, for the simple reason that all the surface water the muck holds will drain off and no more water will be able to rise from below through the hard pan, and thus the soil dries out and crops die off. On the other hand, if the soil belongs to class one and be very deep, it is advisable to burn off some of the surface soil, being careful not to let the fire run too deep, and then put in a system of drains if the subsoil be one of clay or marl.

A sandy subsoil, provided it is not quicksand, may be profitably drained. After drainage subsoiling should be resorted to, when the underlying stratum is of clay, and thus in all probability rich in potash and most likely in Phosphoric acid. The nitrogen is nearly all in the top soil, and potash largely in the subsoil. The chief problem with these particular soils is to bring these two plant foods together in the top soil sufficient for the needs of the growing crop, especially during its earlier growth before its roots reach the lower stratum. This may be accomplished by deeper ploughing, to a depth of 18 inches or so. When the top soil is too deep for this, or the subsoil is sandy, this method of treatment cannot be followed. Many correspondents have remarked that the more they cultivate their swamp soils the better is the crop produced. Along with this, the statement has usually been made that the subsoil has been clay, and they have attributed, and quite correctly, the beneficial result to be due to the intermixture of clay and muck. Besides enriching the soil chemically, the physical texture is much improved also. Burning has already been briefly referred to. Where there is a great depth of top soil this method may be followed, and the remaining soil improved, because the ash produced brings up the balance between the various essential constituents for plant growth: but the danger is that the fire will run too deep and destroy all the

organic matter and leave the soil poor in nitrogen. At best the method is wasteful and should not be followed except in extreme cases and at times when the fire can be controlled.

If, after complete drainage, these soils fail to produce satisfactorily, the defect may arise from one of three causes. The soil may have dried out too completely, which has already been spoken of and the remark made, that such soils had better not be underdrained at all, but used as permanent pastures. Or, the soil may contain excessive amounts of some substance, such as proto-oxide of iron, which is known to be poisonous to plants, or else the soil is deficient in some available form of plant food. It sometimes happens, though rarely, that unproductiveness is due to poisoning from the proto-oxide of iron occurring in excessive amounts. Its presence can be easily detected by the unusually dark colour of the soil, which also assumes a reddish tinge when fresh portions of it are exposed to the air. Such exposure causes the lower oxide (proto-oxide) to take up oxygen and to be converted into the higher "sesquioxide" form which is entirely harmless to vegetation. Where this difficulty arises with a soil, the remedy is to thoroughly break it up and work the soil from time to time so as to expose fresh portions to the air. Often, frequent deep ploughing and harrowing during a single season will remedy the matter. When this has been done and the land is in good tilth, its failure can usually be attributed to a lack of available plant food. This will need to be supplied by application of the proper fertilizers; then by giving attention to these, the principal points that confront the farmer, it ought to be an easy matter for him to bring most varieties of swamp soils into a profitable state of cultivation.

In certain cases where it has been conclusively shown that little else but golden rod will thrive on these soils, or rather grow at all, there is but one course to follow, namely, reforestation, with tamarac, cedar, etc., or such trees as were formerly present and as are adapted to swamp conditions. In this way large areas that are at present unprofitable may be made to yield profitable returns.

USE OF MUCK AS A FERTILIZER.

In cases where it will not pay to drain and cultivate muck areas, a profitable use may be made of it as a fertilizer applied to sandy soils to increase the humus material in them. It is best to draw the muck during the summer. Pile it in heaps and allow it to drain. If acid in nature, it is as well to mix it with some quick lime and allow the whole to slake. After drying it can either be applied to the land immediately, or, better still, it can be used as an absorbent in stables, for which purpose it is very valuable, many mucks having the power of absorbing more than their own weight of liquid. When muck is mixed with urine it readily undergoes fermentation, which increases its fertilizing value. The brown mucks are much quicker in their action than the black:

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Ontario Department of Agriculture

FRUIT EXPERIMENT STATIONS.

FRUITS RECOMMENDED FOR PLANTING

IN VARIOUS PARTS OF THE PROVINCE OF ONTARIO, AFTER CAREFUL TESTS OF VARIETIES MADE AT THE VARIOUS FRUIT EXPERIMENT STATIONS, AND BY EXPERIENCED GROWERS.

FRUIT EXPERIMENT STATIONS.

ADVISORY BOARD, 1910.

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EXPLANATORY REMARKS.

General Lists. After testing a large number of varieties of fruit at the various fruit stations, the Advisory Board has decided upon the following as the most desirable for general planting.

District Lists. The District Lists given by the various experimenters show varieties especially adapted to the sections represented by

their stations. In this bulletin prominent fruit growers in various districts have supplemented the lists previously published, which in some cases were incomplete. The boundaries given for the various districts are merely suggestive, as it is impossible to define these definitely, one merging gradually into the other.

The term *Commercial* is intended to include the varieties most desirable for market purposes, and the term *Domestic* those most desirable for home uses, either cooking or dessert.

These lists are given, as far as possible, in the order of ripening.

It is realized that there are many varieties not included in these lists which may do well *under special conditions*, yet which are generally not considered so desirable as those mentioned.

The Advisory Board recognizing the great disadvantage which faces inexperienced persons who desire to engage in fruit growing for profit, because of the very large and confusing list of varieties, has ordered the publication of these select lists of tested varieties which shall serve as a guide to intending planters. The practice in modern horticulture is to reduce the number of varieties of a fruit planted to within possibly a half-dozen varieties in an orchard. This is to be commended for the commercial orchard specially, and the following lists should be used from which to select such varieties.

GENERAL LISTS OF THE MOST VALUABLE VARIETIES FOR MARKET APPROVED BY THE BOARD OF CONTROL.

APPLES.

Summer.

Astrachan: Adapted to all sections except the extreme north.

Duchess: Adapted to all sections.

Fall.

Gravenstein: Adapted to all sections except the St. Lawrence River and other northerly portions of the Province.

Wealthy: Particularly valuable for northern sections.

Alexander: Especially for northern districts.

McIntosh: Adapted especially to the St. Lawrence River district, but can be grown over a much wider area.

Fameuse: Adapted especially to the St. Lawrence River district, but succeeds well over a much wider area.

Blenheim: Adapted to all sections except the St. Lawrence River district and other northerly portions of the Province.

Winter.

King: Adapted only to the best apple sections, and succeeds best when top-grafted on hardy stocks.

Hubbardston: Adapted to the best apple sections.

Greening: Adapted to the best apple sections.

Baldwin: Succeeds best on clay land, and is adapted to the best apple districts.

Northern Spy: Adapted to the best apple districts, but can be grown with success farther north by top-grafting on hardy stocks. This is also a good method of bringing it into early bearing.

Cranberry: Succeeds best in the eastern winter apple districts, the tree, however, being slightly tender when young.

Stark: Adapted to best apple districts.

VARIETIES ESPECIALLY ADAPTED TO HOME USE.

Summer.

Transparent: Adapted to all sections.

Primate: Adapted to best apple sections.

Sweet Bough: Adapted to best apple sections.

Duchess: Adapted to all sections.

Fall.

Chenango: Adapted to best apple sections.

Gravenstein: Adapted to best apple sections.

Wealthy: Especially adapted to northern sections.

McIntosh: Especially adapted to northern sections.

Fameuse: Especially adapted to northern sections.

Blenheim: Adapted to best apple sections.

Winter.

King: Adapted to best apple sections. Should be top-grafted.

Wagener: Adapted to best apple sections.

Swayzie: Adapted to all sections except most northerly.

Greening: Adapted to best apple districts.

Tolman: Adapted to best apple districts.

Northern Spy: Adapted to best apple districts, but will succeed farther north if top-grafted.

HARDY APPLES RECOMMENDED FOR SECTIONS NORTH OF LATITUDE 46 DEGREES.

Summer.

Transparent, Lowland Rospberry, Charlamoff.

Fall and Winter.

Duchess, Wealthy, Hibernial, Longfield, Patten, Whitney, Hyslop, Milwaukee.

CRAB APPLES.

Whitney: A large crab of high quality, suitable for planting in the extreme north where other apples will not succeed. May be used for dessert or cooking.

Martha: An early crab of fair quality.

Transcendent: Yellowish crab, season early autumn.

Hyslop: Dark, rich, red crab, of late season, quality only fair.

CHERRIES.

Hardy varieties suitable for any portions of the Province bounded by Lakes Ontario, Erie, Huron and the Georgian Bay: Orel, Richmond, Montmorency, Russian 207. For southern sections see district lists.

PEACHES.

GENERAL LIST FOR NIAGARA DISTRICT ONLY.

Commercial: *Alexander, St. John, †Early Crawford, *Champion, †Brigdon or Garfield, †Fitzgerald, †Reeves, †Niagara, Elberta, *Oldmixon, Beers Smock.

Domestic: Hynes, St. John, Early Crawford, Oldmixon, Crosby, Stevens, Lemon Free.

*Should be planted with caution and must receive high culture.

†Very similar and any of these varieties may be set, but all are not needed to cover the season.

PEARS.

Commercial: Giffard, Clapp, Bartlett, Boussock, Flemish (hardy, subject to spot), Howell, Louise, Duchess, Bosc, Clairgeau, Anjou, Kieffer.

Domestic: Summer Doyenne, Giffard, Bartlett, Flemish (for the north), Sheldon, Seckel, Bosc, Anjou, Lawrence, Josephine, Nelis.

PLUMS.

COMMERCIAL AND DOMESTIC:

Americana: These are extremely hardy and desirable where the European and Japanese varieties cannot be grown; Aitkin, Cheney, Bixby, Mankato, Wolf, Hawkeye, Stoddard.

European: Bradshaw, Imperial Gage, Gueii, Shipper Pride, Lombard (liable to overbear, requires thinning), Quackenboss, Yellow Egg, Grand Duke, Golden Drop (Coe), Reine Claude (one of the best for canning).

Japanese: These are apparently quite as hardy as the European varieties: Red June, Abundance, Burbank, Chabot, Satsuma (red fleshed, desirable for canning).

QUINCES.

Fuller, Orange (the leading market variety in Ontario), Champion (for Southern Ontario only, as it ripens too late for other sections).

GRAPES.

COMMERCIAL AND DOMESTIC:

Black: Moore, Campbell, Worden, Concord, Wilder.

Red: Delaware, Lindley, Agawam, Vergennes.

White: Diamond, Niagara.

FOR NORTHERN SECTIONS:

Black: Champion, Moore, Campbell, Worden.

Red: Moyer, Brighton, Delaware, Lindley.

White: Winchell, Diamond.

BLACKBERRIES.

Agawam, Snyder, and for southern sections, Kittatinny.

CURRENTS.

Black: Black Victoria, Champion, Lee, Naples, Saunders.

Red: Cherry, Fay, Pomona, Red Cross, Victoria, Wilder.

White: Grape.

GOOSEBERRIES.

American Varieties: Pearl, Downing, Red Jacket.

English Varieties: Crown Bob, Whitesmith. Not recommended on account of mildew unless to be thoroughly sprayed with the lime sulphur mixture.

RASPBERRIES.

Black: Hilborn, Older, Gregg, Smith Giant.

Purple: Columbian, Shaffer.

Red: Marlboro, Herbert, Cuthbert.

White: Golden Queen.

STRAWBERRIES.

Commercial: Bederwood (P.), Splendid (P.), Warfield (Imp.) not suited to light sandy soil, Greenville (Imp.), Williams (Imp.), Saunders (P.), Sample (Imp.), Irene (Imp.), Buster (Imp.).

Domestic: Excelsior (P.), Splendid (P.), Dunlap (P.), Ruby (P.), Bubach (Imp.), Lovett (P.), Irene (Imp.), Belt (P.).

Note: These varieties vary somewhat in order of their ripening season. In selecting varieties for planting, perfect-flowered varieties should be included to fertilize those having imperfect flowers.

NIAGARA DISTRICT.

(Including the Niagara Peninsula from the Niagara River to Hamilton and north of the escarpment.)

ROBT. THOMPSON, ST. CATHARINES.

APPLES:

Commercial: Astrachan, Duchess, Gravenstein, Blenheim, Cranberry, Hubbardston, King, Greening, Baldwin, Spy.

Domestic: Harvest, Sweet Bough, Duchess, Gravenstein, Fall Pippin, Fameuse, Wagener, Spitzenburg, Jonathan, Tolman.

PEARS (for long distance shipments): Gifford, Clapp, Bartlett, Bosc, Duchess, Anjou, Kieffer (in limited numbers).

PLUMS: Red June, Shiro, Burbank, Arctic, German Prune, Grand Duke, Monarch, Reine Claude.

STRAWBERRIES (for long distance shipments): Williams, Brandywine.

E. D. SMITH, WINONA.

CHERRIES:

Sour: Richmond, Montmorency, Large English Morello.

Sweet: White—Gov. Wood, Napoleon.

Black—Knight, Tartarian, Mezel, Windsor, Schmidt Bigarreau (for clay only).

MURRAY PETTIT, WINONA.

PEARS: Giffard, Bartlett, Howell, Louise, Duchess (dwarf), Anjou, Kieffer.

PLUMS: Burbank, Bradshaw, Lombard, Grand Duke, Monarch, Reine Claude.

GRAPES:

Black: Champion, Worden, Wilder.

Red: Delaware, Lindley, Agawam, Vergennes.

White: Diamond, Niagara.

S. H. RITTENHOUSE, JORDAN HARBOR.

PEACHES: St. John, Early Crawford, Fitzgerald, Elberta, Lemon Free, Beers Smock.

RED RASPBERRIES: Marlboro, Cuthbert.

STRAWBERRIES: Dunlap, Brandywine, Williams.

W. C. MCCALLA, ST. CATHARINES.

PEACHES: St. John, Early Crawford, Fitzgerald, Niagara, Elberta, Late Crawford, Chairs, Smock. (From prices received this year it looks as if this variety may have been overplanted.)

F. G. STEWART, HOMER.

CHERRIES:

Sour: Richmond, Montmorency. (The English Morello, Ostheim and Wragg ripen late here, and are apt to be stung before they are harvested.)

Sweet: White—Gov. Wood, Elton, Napoleon, Spanish.

Black—Tartarian, Elkhorn, Windsor.

J. W. SMITH & SONS, WINONA.

PEACHES: Triumph (5); Leamington (5); St. John (15); Early Crawford (10); New Prolific (10); Champion (5); Rareripe (10); Elberta (20); Late Crawford (5); Lemon Free (10); Smock (5).

The figures refer to the percentages of each variety that this firm recommends for planting.

H. STC. FISHER, QUEENSTON.

PEACHES:

Commercial: Sneed (White), Triumph, Carman (White), St. John, Fitzgerald, Jacques, Reeves, Niagara, Elberta, Late Crawford, Beers Smock.

Domestic: Triumph, St. John, Fitzgerald, Reeves, Champion (White), Chairs, Longhurst.

Note:—The Triumph requires a rich sandy loam well fertilized every year with well-rotted compost manure applied during early winter, and in spring just before plowing a heavy application of muriate of potash and pure bone. Proper pruning of tree and thinning of fruit are also required.

FONTHILL DISTRICT.

(Including Townships of Pelham, Stamford and Thorold.)

E. MORRIS, FONTHILL.

APPLES: Transparent, King, Baldwin, Spy, Mann.

CHERRIES:

Sour: Richmond, Montmorency.

Sweet: Napoleon, Schmidt Bigarreau.

PEACHES: St. John, Jacques, Fitzgerald, Elberta, Smock.

PEARS: *Standard*: Clapp, Bartlett, Clairgeau and Anjou.

PLUMS: Abundance, Bradshaw, Lombard, Monarch, German Prune, Reine Claude.

GRAPES:

Black: Campbell, Worden, Wilder, Concord.

White: Niagara.

BLACKBERRIES: Eldorado, Gainor, Ward, Blowers.

CURRENTS:

Black: Lee, Champion.

Red: Fay, Prince Albert.

White: Grape, Imperial.

GOOSEBERRIES:

American: Pearl, Downing.

English: Keepsake, Victoria, Whitesmith.

RASPBERRIES:

Black: Cumberland.

Red: Herbert, Cuthbert, Ruby.

G. C. BROWN, FONTHILL.

CHERRIES:

Sour: Richmond, Montmorency.

Sweet: Tartarian, Knight, Napoleon.

PEACHES: Triumph, Greensboro, St. John, Fitzgerald, Elberta, Golden Drop or Banner, Smock.

GRAPES: Moore, Worden, Niagara, Delaware, Concord.

CURRENTS:

Red: Cherry, Perfection, Prince Albert.

RASPBERRIES:

Red: Cuthbert.

STRAWBERRIES: Lovett, Williams, Sample.

BURLINGTON—OAKVILLE DISTRICT.

(Including the southern part of the counties bordering on Lake Ontario between Hamilton and Toronto.)

A. W. PEART, BURLINGTON.

APPLES:

Commercial: Duchess, Wealthy, Ribston, Blenheim, King, Baldwin, Spy.

Domestic: Sweet Bough, Duchess, Wealthy, Ribston, King, Wagener Seek, Tolman, Spy.

CHERRIES:

Commercial: Dyehouse, Richmond, Windsor, Montmorency, English Morello.

Domestic: May Duke, Windsor, Montmorency.

PEACHES: Sneed, Alexander, St. John, Early Crawford, Champion, Elberta, Smock.

PEARS:

Commercial: Wilder, Clapp, Bartlett, Boussock, Louise, Duchess (dwarf), Anjou, Kieffer, Lawrence, Nelis.

Domestic: Wilder, Bartlett, Seckel, Louise, Anjou, Nelis.

PLUMS:

Commercial: (EUROPEAN), Bradshaw, Niagara, Imperial Gage, Lombard, Prince of Wales, Yellow Egg, Reine Claude, Staunton.

JAPANESE: Red June, Abundance, Burbank.

Domestic: Saunders, Niagara, Imperial Gage, Orleans, Lombard, Prince of Wales, Yellow Egg, Reine Claude.

GRAPES:

Black: Moore, Worden, Concord.

Red: Moyer, Delaware, Wyoming, Lindley, Vergennes.

White: Diamond, Niagara.

BLACKBERRIES: Snyder, Western Triumph, Agawam.

CURRENTS:

Black: Lee, Naples, Saunders, Collins, Champion.

Red: Cherry, Fay, Pomona, Wilder, Victoria, North Star, Prince Albert.

White: Grape, Imperial.

GOOSEBERRIES: Pearl, Downing, Red Jacket.

RASPBERRIES:

Red: Marlboro, Herbert, Cuthbert.

STRAWBERRIES: Bederwood, Dunlap, Williams, Gibson, Glen Mary, Leader.

W. G. HORNE, CLARKSON.

APPLES: Astrachan, Duchess, Wealthy, Baldwin, Greening, Spy.

PEARS: Bartlett, Anjou.

RASPBERRIES: Cuthbert.

STRAWBERRIES: Sample, Williams, Glen Mary.

LAKE ERIE DISTRICT.

(Including approximately the Counties of Welland, *excluding Fonthill District*, Haldimand, Norfolk and Elgin.)

JAS. E. JOHNSON, SIMCOE.

APPLES: Wealthy, Fameuse, McIntosh, Baldwin, Greening, King, Spy.
STRAWBERRIES: Warfield, Dunlap, Splendid, Sample, Enhance.

ESSEX PENINSULA.

(Including Essex, Kent and Pelee Island.)

J. L. HILBORN, LEAMINGTON.

APPLES:

Commercial: Duchess, Blenheim, Baldwin, Stark, Hubbardston, Spy.

Domestic: Transparent, Golden Sweet, Duchess, King, Tolman, Spy.

CHERRIES: Richmond, Montmorency, Windsor.

PEACHES:

Commercial: Dewey, St. John, New Prolific, Engle, Kalamazoo, Elberta, Banner, Golden Drop, Lemon.

Domestic: St. John, Mountain Rose, Oldmixon, Barnard, Crosby, Lemon.

PEARS: Bartlett, Anjou, Duchess.

PLUMS:

Commercial: Burbank, Lombard, Imperial Gage, Yellow Egg, Reine Claude.

Domestic: Imperial Gage, Bradshaw, Reine Claude.

GRAPES:

Commercial:

Black: Champion, Moore, Concord.

Red: Brighton, Vergennes, Catawba.

White: Diamond, Niagara.

Domestic:

Black: Moore, Worden, Herbert.

Red: Delaware, Vergennes, Catawba.

White: Diamond, Niagara.

BLACKBERRIES: Mersereau, Eldorado, Kittatinny.

CURRANTS:

Black: Victoria, Champion.
Red: Cherry, Fay, Wilder.
White: Grape.

GOOSEBERRIES: Pearl, Downing, Whitesmith.

RASPBERRIES:

Black: Kansas, Hilborn, Gregg.
Red: Marlboro, Cuthbert.
Yellow: Golden Queen.
Purple: Columbian.

BRANT DISTRICT.

(Including Counties of Brant, Oxford, Middlesex and southwestern part of Perth.)

J. C. HARRIS, INGERSOLL.

APPLES:

Summer: Duchess.
Autumn: Blenheim, Gravenstein, Ribston, Alexander.
Winter: Greening, Baldwin, King (top grafted), Spy, Stark.

RASPBERRIES: Cuthbert, Columbian.

STRAWBERRIES: Warfield, Dunlap, Bederwood, Haverland, Williams, Sample, Enhance.

C. W. GURNEY, PARIS.

APPLES: Blenheim, King, Baldwin, Spy, Greening.

FOREST DISTRICT.

(Including the County of Lambton.)

D. JOHNSON, FOREST.

APPLES: Baldwin, Greening, Golden Russet, Hubbardston, and (if grafted on Tolman) King and Spy.

CHERRIES: Richmond, Montmorency.

PEACHES: For those parts of the county influenced by the lake: St. John, Fitzgerald, Late Crawford, Engle, Elberta, Smock.

PLUMS: Bradshaw, Imperial Gage, Reine Claude.

RASPBERRIES: Marlboro, Cuthbert.

STRAWBERRIES: Dunlap, Warfield, Williams, Belt, Bederwood.

LAKE HURON DISTRICT.

(Including the Counties of Huron and Bruce.)

A. E. SHERRINGTON, WALKERTON.

APPLES:

Commercial: Duchess, King, Spy.*Domestic*: Astrachan, Duchess, Colvert, Blenheim, McIntosh, Fameuse, King, Greening, Tolman, Spy.

CHERRIES:

Commercial: Richmond, Olivet, Montmorency.*Domestic*: Spanish, Richmond, Olivet, Windsor, Montmorency.

PEARS: Clapp, Bartlett, Louise, Clairgeau, Anjou, Dempsey, Lawrence.

PLUMS:

Japanese: Burbank.*European*: Bradshaw, Purple Egg, Imperial Gage, Shipper Pride, Lombard, Glass, Quackenboss, Yellow Egg, Monarch, Grand Duke, Reine Claude.

GRAPES: Champion, Moore, Worden, Niagara, Concord.

BLACKBERRIES: Agawam, Eldorado.

CURRANTS:

Black: Champion, Naples, Lee, Saunders, Victoria.*Red*: Red Cross, Fay, Cherry, Perfection, Prince Albert.*White*: Grape, Imperial.

GOOSEBERRIES: Pearl, Downing.

RASPBERRIES:

Black: Conrath, Hilborn.*Red*: Marlboro, Herbert, Cuthbert.*White*: Golden Queen, Brinckle Orange.

STRAWBERRIES: Brandywine, Glen Mary, Williams.

GEORGIAN BAY DISTRICT.

(Including northern portions of the Counties of Grey and Simcoe, bordering on the Georgian Bay.)

J. G. MITCHELL, CLARKSBURG.

(For both commercial and domestic purposes.)

APPLES:

Summer: Astrachan, Duchess.

Fall: Gravenstein, St. Lawrence, Alexander, Wealthy, Twenty Oz., McIntosh.

Winter: Greening, King, Baldwin, Spy.

CHERRIES: Richmond, May Duke, Montmorency, Olivet.

PEACHES: Triumph, Fitzgerald, Early Crawford, Late Crawford, Tyhurst, Crosby.

PEARS: Clapp, Bartlett, Flemish, Howell, Bartlett-Seckel, Seckel, Louise, Duchess, Anjou, Clairgeau.

PLUMS: Red June, Washington, Bradshaw, Imperial Gage, Lombard, Quackenboss, Archduke, Monarch, Yellow Egg, Prune de Agen, Golden Drop, Reine Claude.

GRAPES:

Black: Champion, Campbell, Worden.

Red: Delaware, Brighton, Vergennes, Salem.

White: Winchell, Diamond, Niagara.

CURRENTS:

Black: Lee, Champion.

Red: Cherry, Fay.

White: Grape.

GOOSEBERRIES: Houghton, Pearl, Downing, Red Jacket, Industry.

RASPBERRIES:

Red: Marlboro, Herbert, Cuthbert.

Black: Hilborn, Older, Gregg.

LAKE SIMCOE DISTRICT.

(Including the northern and eastern section of Simcoe and northern sections of York and Ontario bordering on Lake Simcoe.)

G. C. CASTON, CRAIGHURST.

APPLES:

Commercial: Duchess, Peerless, Alexander, Wolf, Blenheim, Pewaukee, Stark, Baxter, Fallawater, Seek, and the following if top-worked on hardy stocks: Greening, King, Ontario, Baldwin, Spy.

Domestic: Astrachan, Louise, St. Lawrence, Fameuse, McIntosh, King, Spy.

CHERRIES:

Commercial and Domestic: Orel 24, Ostheim, Lithaur, Russian 207, Montmorency, Bessarabian, Dyehouse, English Morello.

PEARS: Clapp, Bartlett.

PLUMS: Burbank, Staunton.

GRAPES: Campbell, Moyer, Moore, Diamond, Winchell.

BLACKBERRIES:

Commercial and Domestic: Agawam, Eldorado.

CURRANTS:

Black: Naples, Victoria.

Red: Fay, Versaillaise, Cherry.

White: Grape.

GOOSEBERRIES: Pearl, Downing.

RASPBERRIES: Marlboro, Herbert, Cuthbert.

GUELPH DISTRICT.

(Including the high inland Counties of southwestern Ontario, *i.e.*, Wellington, Waterloo, northwestern section of Perth, south part of Grey, Dufferin, and northwest section of Peel and Halton.)

PROF. J. W. CROW, O. A. C., GUELPH.

APPLES:

Commercial: Duchess, Alexander, Wealthy, Fameuse, McIntosh.

Domestic: Astrachan, Duchess, Alexander, Wealthy, Fameuse, McIntosh, Bellflower, Tolman.

CRAB APPLES: Whitney, Martha.

CHERRIES: Richmond, Montmorency.

PEARS: Clapp, Flemish, Seckel, Sheldon, Anjou.

PLUMS: Bradshaw, Imperial Gage, Shipper Pride, Lombard, Reine Claude, Glass.

GRAPES:

Black: Moore.

Red: Moyer.

White: Winchell.

CURRANTS:

Black: Victoria, Champion, Saunders.

Red: Red Cross, Victoria, Fay.

White: Grape.

GOOSEBERRIES: Red Jacket, Whitesmith.

RASPBERRIES:

Black: Older, Smith Giant.

Red: Marlboro, Herbert, Cuthbert.

Purple: Columbian.

White: Golden Queen.

LAKE ONTARIO DISTRICT.

(Including the southern portions of the Counties bordering on the Lake Ontario shore from Toronto to Kingston.)

ELMER LICK, OSHAWA.

APPLES: Gravenstein, McIntosh, Fameuse, Blenheim, Greening, Baldwin (on clay land), Spy.

[If further varieties are required add Golden Russet (for wet spots), Cranberry, Fallawater, Stark (liable to be overplanted)].

W. H. DEMPSEY, TRENTON.

APPLES:

Commercial: Duchess, Gravenstein, Trenton, Alexander, Wealthy, Fameuse, McIntosh, King, Greening, Baldwin, Ontario, Seek, Spy, Tolman, Ben Davis, Stark.

Domestic: Benoni, Primate, Gravenstein, Fameuse, McIntosh, Grimes, Greening, Ontario, Spy, Tolman, Swayzie.

CHERRIES:

Commercial and Domestic: Richmond, Montmorency.

PEARS:

Commercial and Domestic: Giffard, Tyson, Clapp, Boussock, Hardy, White Doyenne, Dempsey, Bosc, Clairgeau, Goodale, Lawrence, Josephine.

P. A. GREER, WELLINGTON.

RASPBERRIES: Cuthbert, Columbian.

STRAWBERRIES: Dunlap.

A. B. ARNOTT, TRENTON.

BLACKBERRIES: Snyder.

GRAPES:

Black: Moore, Worden, Concord.

Red: Brighton, Lindley, Agawam, Massasoit.

White: Niagara, Pocklington.

ST. LAWRENCE VALLEY DISTRICT.

(Including the valley of the St. Lawrence River from Kingston to the eastern boundary of the Province.)

HAROLD JONES, MAITLAND.

APPLES:

Commercial: Duchess, St. Lawrence, Alexander, Wolf, Wealthy, Scarlet Pippin, Fameuse, McIntosh, Baxter, Milwaukee, Tolman, Golden Russet.

Domestic: Transparent, Astrachan, Brockville Beauty, St. Lawrence, Scarlet Pippin, Fameuse, McIntosh, Blue Pearmain, Bellflower, Tolman, Swayzie.

CHERRIES: Richmond, Montmorency, Orel, English Morello.

PEARS: Flemish (if grown in sod). Ritson (not so hardy in fruit bud as Flemish).

PLUMS:

Americana: Aitkin, Bixby, Mankato, Cheney, Wolf, Schley, Brackett, Hawkeye, Stoddard.

European: Glass, Raynes, Mount Royal, Lunn.

GOOSEBERRIES: Golden Prolific, Downing.

RASPBERRIES: Herbert.

STRAWBERRIES: Belt, Williams, Wolverton, Climax, Saunders, Miller.

OTTAWA DISTRICT.

(Including the Ottawa Valley and the eastern portion of the Province not elsewhere enumerated, south of latitude 46 deg.)

W. T. MACOUN, HORTICULTURIST, CENTRAL EXPERIMENTAL FARM,
OTTAWA.

APPLES:

Commercial and Domestic:

Summer: Transparent, Lowland Raspberry, Duchess.

Autumn: St. Lawrence, Wealthy, Alexander.

Early Winter: McIntosh, Fameuse, Wolf.

Winter: Milwaukee, Baxter, Scott.

Additional varieties suggested for domestic use:

Summer: Langford Beauty.

Autumn: Peach of Montreal, McMahon.

Winter: Swayzie, Pewaukee, Golden Russet, Rufus.

CRAB APPLES:

Commercial and Domestic: Whitney, Martha, Hyslop.

CHERRIES:

Domestic Only: Orel 25, Vladimir, Minnesota, Ostheim, Cerise d'Ostheim.

PEARS:

Commercial and Domestic: Flemish in most favored parts.

PLUMS:

Commercial and Domestic:

Americana and Nigra: Aitkin, Bixby, Mankato, Cheney, Wolf, Schley, Brackett, Hawkeye, Stoddard.

European and Domestic: Early Red (Russian), Mount Royal, Glass, Montmorency, Raynes, Perdrigon.

GRAPES:

Black: Early Daisy, Manito, Worden, Merrimac, Wilder.

Red: Moyer, Brighton, Delaware, Lindley.

White: Winchell, Diamond.

BLACKBERRIES:

Domestic Only: Agawam, Snyder.

CURRENTS:

Commercial and Domestic:

Black: Saunders, Kerry, Clipper, Eclipse, Climax, Collins, Prolific, Black Victoria.

Red: Pomona, Victoria, Dutch and Wilder in the most favoured parts.

White: Grape.

GOOSEBERRIES:

Commercial and Domestic: Pearl, Downing and Red Jacket.

RASPBERRIES:

Commercial and Domestic:

Black: Hilborn, Older, Cumberland.

Red: Marlboro, Herbert.

Yellow: Golden Queen.

STRAWBERRIES:

Commercial: Bederwood (P.), Splendid (P.), Warfield (Imp.), not suited to light soil; Greenville (Imp.), Parson Beauty (P.), Pocomoke (P.), Sample (Imp.), Buster (Imp.).

Domestic: Excelsior (P.), Splendid (P.), Dunlap (P.), Lovett (P.), Ruby (P.), Bubach (Imp.), Belt (P.).

The Williams does not seem to do as well in Eastern Ontario as in Western.

ALGOMA DISTRICT.

(Including the islands of Manitoulin and St. Joseph, and a limited portion of the northern and eastern shore of the Georgian Bay.)

CHAS. YOUNG, RICHARD'S LANDING.

APPLES:

Summer: Transparent, Charlamoff, Astrachan.

Autumn: Duchess, Peach, St. Lawrence, Alexander, North Star, Colvert, Gideon.

Early Winter: McIntosh, Winter St. Lawrence, Wolf, Baxter, Longfield, Louise, Wealthy.

Late Winter: Walbridge, Scott, Pewaukee.

Crab Apples: Whitney, Hyslop, Isham.

CHERRIES:

If near the influence of the water, Richmond, Montmorency, English Morello, Orel 25, and Ostheim.

PLUMS:

European: Glass, Lombard, Early Red (Russian), Trabesh (Russian).

Americana: Cheney, Wolf, Hawkeye, Stoddard.

GRAPES: Campbell, Moore, Winchell.

CURRANTS:

Black: Saunders, Champion, Victoria.

Red: Dutch, Versaillaise.

White: Grape.

GOOSEBERRIES: Golden Prolific, Pearl, Downing, Red Jacket.

RASPBERRIES:

Red: Marlboro, Loudon.

White: Brinckle Orange (for quantity only).

 SPECIAL LISTS OF APPLES.

The Department of Agriculture is frequently asked as to the best varieties to plant for specific purposes, such as the home markets, the box apple trade, etc. Some of our growers, in response to inquiries, state that with few exceptions they would plant the same varieties for all markets, choosing standard kinds of high quality, such as King, Spy, and Baldwin for winter use. Others again would specialize, believing that

certain markets prefer and pay higher prices for some varieties as against other kinds which the growers might consider just as valuable. The following lists are submitted as guides to those who may desire to follow out such specializing:

VARIETIES RECOMMENDED FOR IMMEDIATE RETURNS.

W. H. DEMPSEY, Trenton: Duchess, Alexander, Wealthy, Fameuse, Ontario, Seek, Spy.

ELMER LICK, Oshawa: Duchess, Wealthy, Fameuse, Wagener, Stark.

ROBT. THOMPSON, St. Catharines: Duchess, Wealthy, Blenheim, Fameuse, Baldwin, Greening.

J. G. MITCHELL, Clarksburg: Standard winter varieties such as Baldwin, Spy, and King planted 42 feet apart; fillers of the following varieties between, Duchess, Wealthy, Ontario, Alexander. This method to be followed by intensive culture, heavy feeding, pruning, spraying, etc.

VARIETIES SPECIALLY ADAPTED FOR THE WESTERN MARKETS.

W. H. DEMPSEY, Trenton: Duchess, Gravenstein, Alexander, Trenton, Wealthy, Fameuse, McIntosh, King, Greening, Baldwin, Ontario, Seek, Spy.

ELMER LICK, Oshawa: Gravenstein, McIntosh, Fameuse, Blenheim, Greening, Baldwin, Spy.

ROBT. THOMPSON, St. Catharines: Astrachan, Duchess, Gravenstein, King, Blenheim, Fameuse, Baldwin, Greening, Spy.

VARIETIES SPECIALLY ADAPTED FOR EXPORT TO GREAT BRITAIN AND THE CONTINENT.

W. H. DEMPSEY, Trenton: Duchess, Gravenstein, Trenton, Alexander, Wealthy, McIntosh, King, Greening, Baldwin, Fameuse, Ontario, Seek, Spitz, Tolman, Ben Davis, Stark.

ELMER LICK, Oshawa: Gravenstein, McIntosh, Fameuse (these three in boxes), Blenheim, Greening, Baldwin, Spy, Golden Russet, Cranberry, Fallawater, Stark.

J. G. MITCHELL, Clarksburg: King, Baldwin, Spy.

VARIETIES ADAPTED TO LOCAL MARKETS IN ONTARIO AND QUEBEC.

W. H. DEMPSEY, Trenton: All of the varieties previously recommended except Ben Davis.

ELMER LICK, Oshawa: Benoni (if thinned), Gravenstein, McIntosh, Fameuse, Greening, Spy.

ROBT. THOMPSON, St. Catharines: Duchess, Blenheim, King, Baldwin, Greening, Spy, Fameuse, with possibly a few trees of some sweet variety, and a few Ben Davis.

J. G. MITCHELL, Clarksburg: King, Baldwin, Spy.

VARIETIES SPECIALLY ADAPTED TO THE BOX APPLE TRADE.

W. H. DEMPSEY, Trenton: All of the varieties previously recommended, but grow and pack nothing but Fancy No. 1.

ELMER LICK, Oshawa: Gravenstein, McIntosh, Fameuse, Blenheim, Spy, Baxter, King, Wagener.

ROBT. THOMPSON, St. Catharines: Duchess, King, Spy, McIntosh, Baldwin.

J. G. MITCHELL, Clarksburg: Gravenstein, St. Lawrence, Alexander, Fameuse, McIntosh, King, Baldwin, Spy.

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE.

Flour and Breadmaking

By R. HARCOURT AND MISS M. A. PURDY.

INTRODUCTION.

Although flour is one of the most common materials used in the preparation of our foods, very few people have a clear idea of the wide difference between the flour-producing properties of the various varieties of wheat grown in different localities, of the effect of climate, soil, etc., and of the different grades of flour on the market. To many people flour is simply flour, and they know no grades, unless it is simply two kinds—bread and pastry flour. As a matter of fact, there are a great many grades of flour; and, while the millers, particularly those in the larger milling concerns, strive to keep the different grades of flour uniform from year to year, there are wide differences in the quality of the wheat, which is their raw material, that renders this problem a very difficult one, if not impossible. Consequently, the flour got under any one grade is very likely to vary somewhat in strength, or in some of the conditions which would affect the baking. By blending wheats of different grades and varieties of different qualities the miller may be able to produce a uniform sample of flour, but in certain seasons this may be a very difficult problem. Very often the millers are blamed for producing poor flour when the circumstances that effect this are beyond their control.

CIRCUMSTANCES INFLUENCING THE QUALITY OF WHEAT.

There is abundance of evidence to prove that the composition of wheat is influenced by its environment. Millers are quite familiar with the fact that some districts in Ontario will produce a better quality of wheat than others, and that the spring wheat of the Western Provinces is superior to the best Ontario can produce. Possibly climate (including variations due to season) and soil, or, rather, the condition of the soil, have the greatest influence on the composition of the wheat. To obtain a good quality of wheat for milling purposes we require bright, warm

days, with an abundance of sunshine and an absence of an excess of moisture; or, in other words, the conditions which would cause rapid, though normal, ripening of the grain. Wheat that has ripened slowly, or that is over-ripe, is usually somewhat low in protein, and, consequently, in gluten, and rich in starch. Chemical investigations seem to show that at the time of blossoming the plant has taken up nearly all the nitrogen and ash constituents that it will have in the matured plant, while it continues to take up carbon as long as the plant is green. This means that the longer the time from blossoming to maturity the greater the opportunity for the plant to take up carbon and convert it into starch and store it in the grain. Consequently, slowly matured grain will be plump. The amount of protein, or gluten, is determined by the amount of nitrogen taken into the plant in the early stages of growth, and the completeness with which this is transferred to the seed.

A comparatively high temperature, long, bright days, an absence of an excess of moisture, are the conditions which prevail throughout our Western Provinces, and these are, doubtless, some of the conditions that account for the high quality of wheat produced there.

The researches of Laws and Gilbert at the Rothamsted Institution, in England, and of the Central Experimental Farm at Ottawa, show that manures have very little influence on the composition of the wheat. Recent investigations by F. T. Shutt, Central Experimental Farm, Ottawa, show that the amount of moisture in the soil is a greater factor than the amount of nitrogen available to the plant. These investigations indicate that when wheat is grown on two different soils, one of which contains more moisture than the other, the moist soil will produce grain with low gluten and high starch content. This is probably due to the fact that in this case maturity is retarded. It will thus be seen that the wheat from the same localities and of the same variety may be quite different in composition and in milling qualities. Furthermore, it is well known that the wheat from some localities in our own Province is very much superior to the same variety of wheat grown in another locality. Thus, without going too deeply into this point, it will be seen that wheat is not of a constant composition, but that it varies from season to season and in different localities. The composition also varies very widely with different varieties.

VARIETIES OF WHEAT.

Wheats are commonly divided into two great classes—those sown in the autumn and harvested the next summer, known as fall or winter wheats, and those sown in the spring and reaped the same season, known as spring wheats. As a rule, the spring wheats are harder, and make a superior flour for breadmaking purposes. There are a great number of varieties of these two different classes of wheats, which vary very much, not only in the yield of grain and straw per acre, but also in milling and baking qualities.

Some of these varieties are very soft, and yield a poor quality of flour. Unfortunately, these soft wheats usually produce more bushels per acre than the harder, better wheats; and, as the buyer makes very little difference in the price, it naturally follows that the softer, heavy-yielding varieties are grown in largest quantity. We have milled and baked over sixty varieties of fall wheats grown on the college experimental plots in each of the seasons of 1907, 1908, and 1909, and also over forty varieties of spring wheats, grown the same seasons. The results of these tests are too voluminous to incorporate here, but they may be found in the Ontario Agricultural College Reports for 1908 and 1909.

To the Ontario miller the question of the varieties grown in his own district is a very important one, for the greater part of this wheat will probably be delivered at his own mill; and, if the varieties are poor ones, his difficulties in manufacturing a strong flour are increased. Fortunately, there are not a great number of varieties grown in the Western Provinces, and the mixing in transit makes the wheat of more uniform grades than could possibly be done in this Province.

MILLING OF FLOUR.

The roller mill process of making flour is a gradual one. In the old days, when all the flour was ground by the stone process, the whole of the flour was left in one grade, and the germ and some of the bran layers of the wheat were not removed in the bolting process. The consumers' demand for a whiter flour than could be made by this process was partly instrumental in bringing in the roller process of milling, although the introduction of harder varieties of wheat, closer milling, and the division of flour into a number of grades were some of the other reasons for its introduction.

By the roller process the miller has it in his power to separate the flour into as many grades as he chooses, and in the larger mills as many as six grades of flour are made from one stream of wheat. The process is, briefly, as follows:

After being thoroughly winnowed and scoured, the wheat is passed between a pair of corrugated rollers, revolving towards one another, but one travelling slower than the other. In this first "break" the wheat is simply broken open along the crease; the whole of the broken-up material is then separated according to fineness into a number of products. The coarse, main part of the grain is returned to another pair of corrugated rolls, and is ground a little closer; the product is again sifted and the branny part returned to other rolls. This is repeated a fourth, fifth, or even a sixth time, or until practically all the starchy materials are removed from the flat particles of bran. With each sifting some material fine enough for flour is obtained, but the greater part of the endosperm, or central part of the wheat, is left in a coarse, granular

condition, which, when purified, forms the wheat farinas that are sold as breakfast foods under a great number of fanciful names, such as Meat of Wheat, Hearts of Wheat, Wheat Crystals, etc. It is from this same part of the wheat that the whitest and strongest flours are made. The germ is the richest part of the grain in protein and fat; the inner bran layers are the next richest, and the starchy endosperm contains the least of these constituents. It naturally follows that if flour is made from the endosperm it will be whiter, and lower in protein, fat, and crude fibre than if the whole grain was included, or somewhat poorer than if all the flour made from the wheat was left in one grade, as was done in the old stone process, or as is done to-day in making a straight-grade flour.

The names assigned to the various grades of flour are very numerous, as practically every flour miller has special names for his products. But, while there are a number of variations, nearly all flour may be graded as "patent," "bakers'," or "straight." The well known flours, Royal Household, Five Roses, and Purity, are patents which probably form about 35 per cent. of the total flour. Sometimes, however, the term "standard patent" or "long patent" is used to designate a flour which forms about 90 to 95 per cent. of the total flour, and is, consequently, only a little better than a "straight." The "bakers'" grade, or "clears," usually represents about 55 per cent. of the flour after the patents have been taken off. A good bakers' grade of flour will yield about as much bread as a "patent," but the bread is not of so good a colour. The low grade is got by grinding still closer to the bran layers, and represents the remainder of the flour, or about 10 to 15 per cent. of a total flour. The "straight" grade is the whole, or 100 per cent., of the flour from the wheat left in one grade. Of course, the percentage amount of the flour left in the various grades are not fixed, but are varied by every miller, according to the quality of the wheat he is using and the strength and colour of the flour he wishes to produce.

To show the difference in the composition of these different grades of flour the following figures, taken from Bulletin No. 13, part 9, of the Bureau of Chemistry, Department of Agriculture, Washington, are given:

PERCENTAGE COMPOSITION OF WHEAT AND THREE GRADES OF FLOUR
MADE FROM IT.

	Moisture	Fat	Carbo- hydrates	C. Fibre	Ash	Proteids	Gluten	
							Wet	Dry
Wheat	9.07	2.74	70.37	1.68	1.79	14.35	32.31	11.88
Patent	11.48	1.45	73.55	.18	.39	12.95	36.14	10.85
Bakers'	12.18	2.00	69.99	.33	.62	14.88	51.21	16.97
Low grade	12.01	3.86	63.26	.93	1.99	17.95	10.01	4.26

It will be noticed that the low-grade flour contains the most fat, fibre, ash, and proteids, and the least starch and gluten, while the patent flour has the least of the first four named constituents—in every case very much less than the wheat from which it was prepared—and the largest percentage amounts of carbohydrates, or starchy material, and a much larger quantity of gluten, although not so much as the bakers' grade. When we remember that there is more fat, ash, fibre, and proteids in the bran layers than in the endosperm, and that the patent flour is kept as clear as possible of bran particles, we are not surprised that this flour is low in these materials and that it is particularly rich in starch. Because of these facts it is lighter in colour than the other grades; and, because consumers of bread attach so much importance to this question of colour, the patent flours sell for more money than any of the other grades, while, judging by percentage composition, the low grade would appear to be the most nutritious, although, as we shall see later, this does not necessarily follow.

The above named grades of flour are generally made from the hard Western wheats. The softer Ontario wheat may also be separated into as many grades, but it is more commonly sold as a "straight" grade flour, or as a long patent, *i. e.*, a straight grade flour from which 5, 10, or 15 per cent. of low-grade has been removed. As shown earlier, the soft winter wheats contain less protein and more starch than the spring varieties; consequently, as gluten is a part of the proteins, the flours will be lower in gluten. They will also be more starchy, and are generally whiter in colour; these flours are usually sold as pastry flours. Although good bread can be made from them, it is not so suitable for commercial breadmaking as the stronger spring wheat flour. It is generally thought that the soft flours make a sweeter and more palatable loaf of bread, but it will not produce so much, nor will it make so large a loaf, as the stronger flour. Many millers in Ontario make a blended flour, in which there is 30 or 40 per cent. of spring wheat and the balance made up of winter wheat. Most of the bakers use large quantities of the soft flour; but, usually, they prefer to do their own blending, because the two flours do not "work" evenly in the breadmaking process.

There are other grades of flour on the market. Among these possibly the Graham is the most important. This flour, if true to name, should be the whole wheat, ground fine, with no bolting process. Therefore, it should be of the same composition as the wheat from which it is prepared. It is to be feared that very often the material sold for Graham flour does not come up to this standard. Entire-wheat flour is not used to any great extent in this country. In preparing it the outer bran layers are practically peeled off by machinery, and then the remainder of the wheat is reduced to flour.

Gluten flour is a special brand prepared for people troubled with diabetes, or others who cannot use starchy foods.

QUALITY IN FLOUR.

The various kinds of flour dealt with in the preceding paragraphs comprise all those in general use throughout this country. They vary very much in strength, due to the circumstances which cause variation in the quality or strength of the wheat, the milling, the grade, and the kind of flour. Unfortunately, our knowledge of the ultimate composition of the constituents of flour, or the various intricate changes that take place in the making of bread, is not complete enough to make it possible for us to determine by chemical analyses the best breadmaking flour. Within certain limits it is an easy matter to tell which flour will make the best bread. For instance, the flour from hard spring wheat is usually granular, or gritty; and, when squeezed in the hand, does not readily pack, leaving the imprint of the fingers, whereas the soft flours do. The hard, or strong, flours absorb more water and give a better yield of bread. They also have more gluten, which gives them greater expansive properties. In general, the hard flours are usually spoken of as the bread flours and the soft flours as the pastry flours. But when we come to distinguish between the different kinds of strong flours, the feel, or appearance, alone is not sufficient to base a correct judgment regarding the merits of the two flours, nor will chemical analyses aid us materially.

The baker likes a flour that will absorb a large amount of water, yield a large loaf of a desirable shape, with good colour and texture. Such a flour is usually spoken of as a strong flour, but if we look deeper and attempt to define "strength" in flour, we find many conflicting views. Jago defines strength as the capacity of a flour for absorbing water, and treats separately the qualities of size, shape, colour, and texture.¹ Humphries' and Biffin's definition of strength is the "capacity for making large well-piled loaves."² This definition suggests that the primary factor is the size of the loaf, the other factors being shape and, perhaps, to some extent, texture.

If we try to explain the factors that influence the volume, texture, and shapeliness of a loaf of bread, the conflict of views is even more in evidence. The oldest idea suggested that, because of the tenacity of the gluten, the carbon dioxide produced in the dough by the action of yeast was retained, and caused the dough to rise. No doubt a large amount of gluten is frequently associated with large volume and good texture, but there are apparently other factors that influence the result, for there are many cases in which the flour with the highest content of gluten does not give the largest loaf. Attention was called to the fact that some glutes were soft and flabby, while others were firm and tenacious, and attempts were made to ascertain the quality of glutes by determining the relation between the weights of wet and dry glutes.

¹Jago, *The Science and Art of Breadmaking*, London, Simpkin, Marshall & Co., 1895.

²Humphries and Biffin, *Journ. Agric. Sci.*, Vol. II., Pt. I., p. 1.

their expansion power under the influence of heat, the proportion of gliadin to glutenin, which together make gluten, etc. But none of these methods have been entirely satisfactory. Recently it has been suggested that it is not the ratio of gliadin and glutenin, but the absolute amount of gliadin which gives strength to a flour. This also has been discredited. Finally, an entirely new theory has been suggested, *i.e.*, that the size of a loaf is not so much dependent upon the quality or quantity of the gluten as upon the amount of sugar contained in the flour, together with that formed in the dough by diastatic action, and that shapeliness, and probably gas retention, are dependent on the physical properties of the gluten as modified by the presence of varying proportions of salts.

From what has been said, it is evident that our knowledge, or lack of knowledge, of the chemistry of flour and breadmaking is another instance of the fact that many of the most common materials and everyday operations around us are the least understood. Frankly, we do not know enough about chemistry of flour, or of the changes that the various constituents undergo in the process of breadmaking, to devise any system of chemical analysis that will give conclusive and satisfactory evidence of the strength of flour for breadmaking purposes. Therefore, the only available method of determining the relative value of flour for bread purposes is by actual baking trials.

In all our baking trials nothing but a little sugar, salt and lard, in addition to the yeast and water, was added to the flour. In order to bring out the full expansive power of the flour, a rather large quantity of yeast was used. The conditions were kept as uniform as possible, but each loaf was placed in the oven when it had risen sufficiently and the general appearance indicated that it was ready for baking.

QUALITY OF THE DIFFERENT KINDS OF FLOUR.

It is impossible to bring out here all the differences in quality of the bread of the various kinds of flour. Fig. 1 shows the average size of the loaf of bread made from equal weights of the Western hard spring wheat flour and our soft Ontario winter wheat flour. The former is a good bread flour; it has more and better gluten, greater water absorptive power, greater expansion, and, in every respect but that of flavor, produces a more desirable loaf than the latter. Good bread can be and is being made every day from the soft wheat flour; but, while it may be preferred by some people, it will not make bread that will supply the demand of the bakers' customers so well as the stronger flour.

Fig. 2 shows loaves of bread from several of the grades of flour made from one stream of the Manitoba wheat, while the accompanying table gives the figures showing the percentage of gluten and the water absorption of the flours, the weight and size of the several loaves, and

the quality of the bread. Exactly 12 ounces of flour was used in making each loaf. To secure figures showing the comparative quality of the bread, that made from the patent flour was taken as a standard and given 100 points for color, texture and appearance, and the other loaves were marked in percentage of the standard. The quality of the bread from the low grade and red dog was so poor that it could not be compared with that from the patent flour.

Flour	Percent of wet Gluten	Percent of water absorbed	Weight of Loaf *Grams	Size of Loaf Cubic in.	Quality of Loaf		
					Color	Texture	Appearance
Patent	32.16	66.5	522	162.26	100.0	100.0	100.0
Bakers'	34.46	65.6	515	160.43	97.0	99.0	100.0
Straight Grade	34.09	65.9	517	160.43	96.0	99.0	100.0
Low Grade	41.13	72.4	530	145.18			
Red Dog	30.68	78.2	524	145.18			

*28.34 grams in 1 ounce.

The first three loaves are very similar in appearance, but, although the patent flour contained the least gluten, it was able to absorb the most water and gave a slightly heavier and larger loaf of bread that was superior in color and texture to that obtained from the bakers' grade. The straight grade is, as might be expected, a fairly strong flour, but darker in color than the patent or bakers' grades. The low grade flour made a loaf of fair size, but in color and texture it was so poor that no strict comparison could really be made with the higher grades. The water absorption of the low grade flours, especially of the red dog, is very high and the weight of the loaf is correspondingly high. The patent flour made the largest loaf, and the red dog the smallest. The dark, branny flours are always high in absorption, but produce a very small, sodden loaf of bread which does not give much surface for evaporation of water, and is, consequently, very heavy and of poor quality.

It is evident that the first three flours are of good quality for making bread, while the fourth, or low grade, is poor in quality, although it contains fully as much food materials as that from the higher grades. The red dog flour may be used in making dog biscuits, or sold for cattle feed, but is seldom manufactured into bread.

In Fig. 3 we have a photograph of seven loaves of bread from seven different varieties of wheat grown on the Experimental plots of the Ontario Agricultural College. This cut illustrates the wide variation in the quality of the bread the different varieties are capable of producing. The comparison is more fully brought out by a study of the figures given in the following table:



Fig. 1. Bread from straight grade flour made from, 1st, Manitoba wheat; and 2nd, Ontario Winter wheat.

Flour	Percent of Gluten	Percent of water absorbed	Weight of loaf *grams	Size of loaf Cubic in.	Quality of loaf.		
					Color	Texture	Appearance.
Bulgarian	26.87	47.4	458	128.71	97.0	97.0	100.0
Early Red Clawson	25.87	48.8	464	100.04	97.5	96.0	93.0
Kentucky Giant	27.10	48.8	460	120.78	99.0	102.0	95.0
Early Genesee							
Giant	26.87	48.8	459	132.37	100.0	100.0	100.0
Geneva	28.40	47.4	462	115.90	98.0	97.5	98.0
Dawson's Golden							
Chaff	22.50	48.8	473	111.63	90.0	94.0	96.0
Egyptian Amber	27.50	48.8	475	127.49	99.0	7.90	100.0

*28.34 grams in 1 ounce.

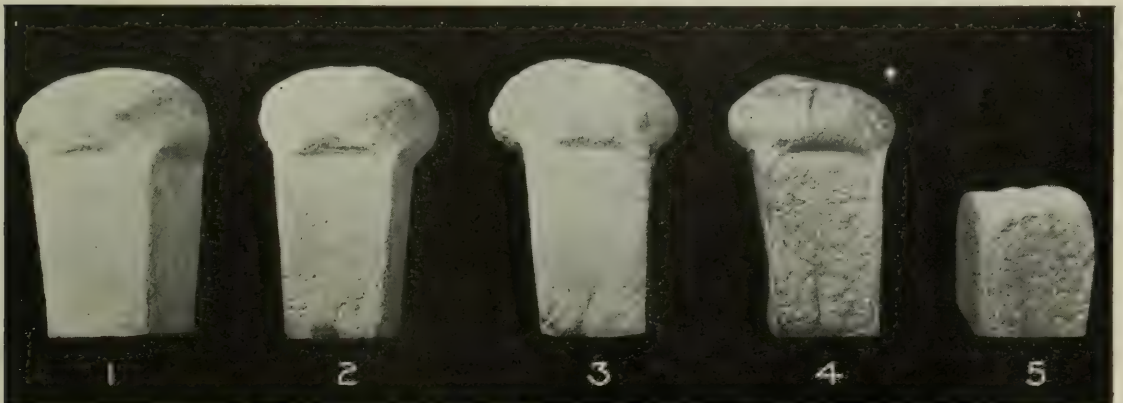


Fig. 2. Bread from five grades of flour made from one stream of Manitoba wheat. No. 1, Patent; No. 2, Baker's grade; No. 3, Straight grade; No. 4, Low grade; No. 5, Red dog.

Egyptian Amber gave the best yield of bread, the Early Genesee Giant the largest loaf, and the best quality of bread, while Dawson's Golden Chaff and Early Red Clawson gave the smallest loaves and the poorest quality of bread. In Fig. 4 the cut loaves of Nos. 2 to 6, inclusive are shown. Note the coarse, open texture of Dawson's Golden Chaff and the Early Red Clawson, and the nicely rounded shape of the loaves from Early Genesee Giant and Geneva.

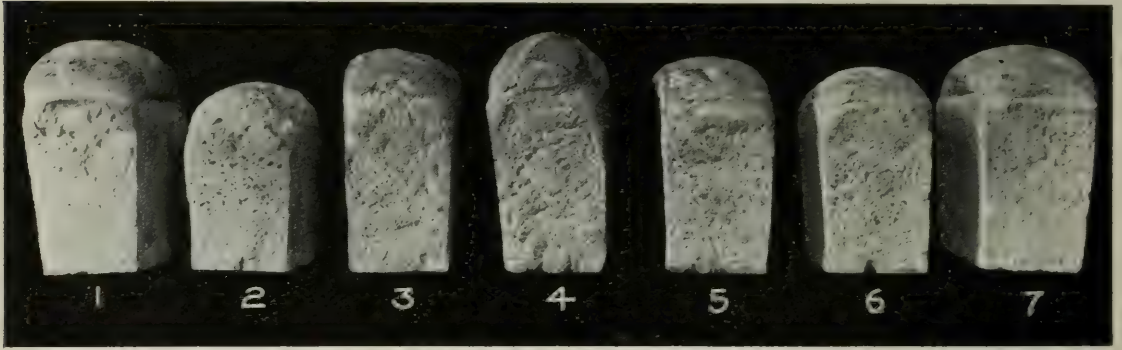


Fig. 3. Bread from seven Winter wheats grown on Experimental plots, Ontario Agricultural College.

No. 1, Bulgarian; No. 2, Early Red Clawson; No. 3, Kentucky Giant; No. 4, Early Genesee Giant; No. 5, Geneva; No. 6, Dawson's Golden Chaff; No. 7, Egyptian Amber.

Previous mention was made of the fact that some localities produced a better quality of wheat than others. Fig. 5 shows the difference in size of two loaves of bread made from Ontario winter wheat grown in two different localities. The larger loaf was also much superior in color, texture and general appearance. It is evident that the millers in the locality in which the stronger wheat is grown, or those who buy from this district, have an advantage over the unfortunate ones who have to use the weaker wheat.



Fig. 4. Cut-surface of loaves shown in Fig. 3.

No. 1, Early Red Clawson; No. 2, Kentucky Giant; No. 3, Early Genesee Giant; No. 4, Geneva; No. 5, Dawson's Golden Chaff.

Again, as shown in Figs. 3 and 4, the general quality of the wheat in any section will vary as the predominating varieties are of the stronger or weaker sorts. The miller grinds a mixture of varieties, usually striving to use enough of the stronger varieties with the weaker sorts to keep up a good quality of flour; but, unless he is catering to some special trade, he does not pay so much attention to uniformity of grade as when the stronger and usually more expensive flours are being made. In the case of the Western wheats, the same difference exist between varieties, localities in which it is grown, and the condition of the soil producing it, etc.; but most of this wheat is graded and passes through the elevators where all the wheat of the same grade is mixed together; consequently, unless the miller can buy from desired districts and ship by car directly to his own mill, he cannot control the selection of the wheat very much.

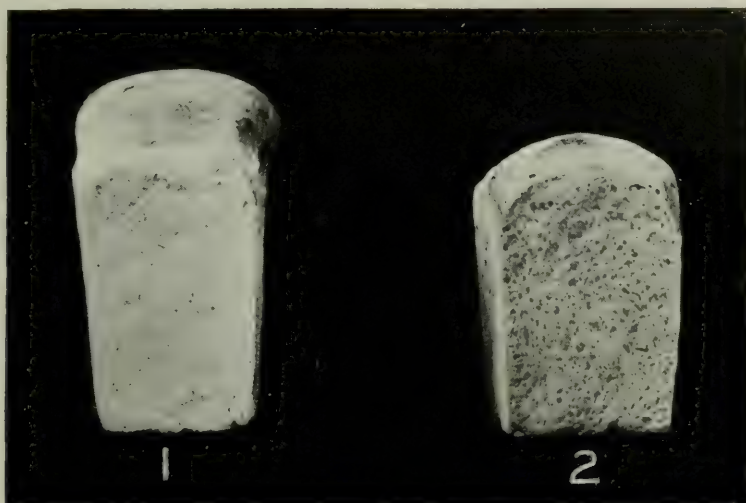


Fig. 5. Bread from Ontario Winter wheat grown in different localities.

BLENDING FLOUR.

This mixing of varieties of wheat from different localities is blending to secure certain results; but, what is commonly known as blended flour is made by grinding some of the soft Ontario wheats with the harder wheats from the West.

The object of blending flours is partly for economy, as the soft wheat is usually cheaper than the hard, and partially to secure the flavour of the one and the expansion and texture of the other. They are usually spoken of as "general purpose" flours, or as "household" flours.

In Fig. 6 we have an illustration of the effect of blending different proportions of the hard with the soft. Loaf No. 1 is made from an 85 per cent. Manitoba flour, and No. 7 is made from an 85 per cent. soft flour. No. 6 contains 20 per cent. of the Manitoba flour and 80 per

cent. of the Ontario flour. No. 5 contains 30 per cent. of the Manitoba and 70 per cent. of the Ontario flour, and Nos. 4, 3 and 2 contain 40, 50 and 60 per cent., respectively, of the strong flour. Note the increase in size with the increased proportion of the stronger flour.

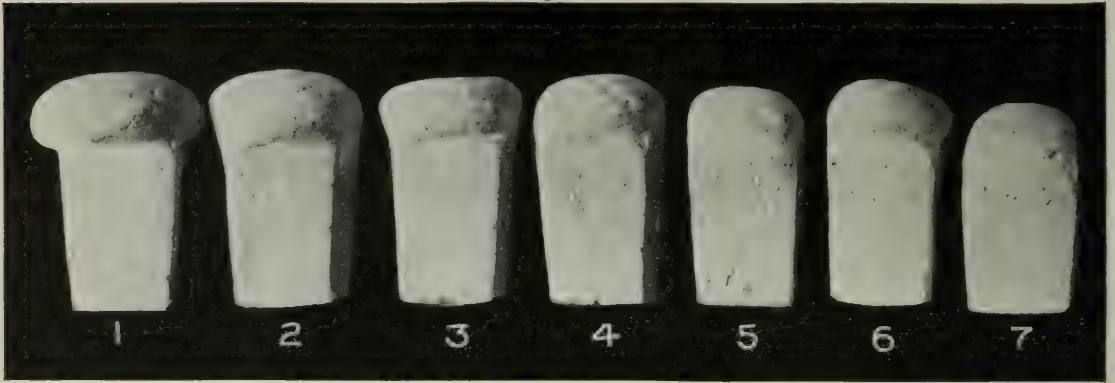


Fig. 6. Loaves of bread made from Manitoba and Ontario flours blended in following proportions:

No. 1	.....	100%	of Manitoba						
No. 2	.....	60%	"	"	and 40%	Ontario soft flour.			
No. 3	.....	50%	"	"	"	50%	"	"	"
No. 4	.....	40%	"	"	"	60%	"	"	"
No. 5	.....	30%	"	"	"	70%	"	"	"
No. 6	.....	20%	"	"	"	80%	"	"	"
No. 7	.....				"	100%	"	"	"

The following table gives figures showing the change in yield of bread, the size and quality of the loaf of bread produced in each case. Twelve ounces of flour was used in making each loaf.

Flour	Percent of gluten	Percent of water absorbed	Weight of loaf *grams	Size of loaf Cubic in.	Quality of loaf.		
					Color	Texture	Appearance
No. 1	34.09	68.8	523	167.0	100.0	100.0	100.0
No. 2	32.31	66.2	507	162.9	99.0	99.0	98.5
No. 3	31.86	64.6	495	146.4	98.0	98.5	96.0
No. 4	31.41	62.5	496	145.8	97.0	98.0	95.0
No. 5	28.97	61.4	489	125.7	96.0	96.0	92.0
No. 6	30.52	60.9	490	115.9	95.0	95.0	90.0
No. 7	29.63	52.2	477	111.6	94.0	94.0	87.0

*28.34 grams in 1 ounce.

A common blend used by the millers is 40 per cent. of the strong flour and 60 per cent. of the weaker Ontario flour. It will be seen that while the bread from this blend is not equal to that from the all strong flour, it is a good loaf in every respect.

BLEACHING.

Every experienced baker knows that newly made flour does not give so satisfactory results in breadmaking as flour that has been aged by storing in a suitable place for two or three months. Why this should be so is not definitely known. There is probably a slight drying out of the flour which would naturally increase its water absorptive capacity. The expansive power is also increased and the flour is improved in colour. Bleaching the flour by chemical means appears to have a somewhat similar effect as that brought about by ageing; but, while a freshly milled bleached flour is better for breadmaking than the fresh unbleached article, the artificial bleaching will never make a flour equal in quality to that obtained under the ordinary conditions of ageing.

The results of bleaching are most plainly seen in the change of colour; the flour becomes whiter or bleached in appearance, but it has not the same desirable creamy shade that is obtained by natural ageing. However, because of the general preference for the whitest bread, a freshly made bleached flour will usually sell for more money than the same flour unbleached. As a general rule, only the better grades of flour are bleached. The cost of treatment is small and the action, while not instantaneous, is rapid.

BREADMAKING.

The object of the miller is to make all the flour that is possible from the wheat at his disposal and to separate this into the grades demanded by his customers. The baker's part is to make from the flour the maximum amount of bread of a good quality. To do this intelligently, he should not only be familiar with the methods of manipulation, **but he** should also understand the nature of the materials he is working with, **and**, so far as is possible, the chemical and physical changes brought about during the process.

We have dealt with flour and it now remains for us to discuss some of the more important leavening materials and the changes which these and other agencies cause in the dough.

LEAVENING MATERIALS

Yeast.

Yeasts are the natural agents which cause the fermentation of bread dough, familiar to every housewife as "raising." This fermentation of bread has been known almost as long as we have any recorded history, for early Bible writers tell of leavened and unleavened bread, the former being raised with leaven (which we now know was yeast), and the latter being baked without previous raising. Although this phenomenon of the fermentation of bread was thus known from very early times, its real cause was not definitely proven until the last century, when between the years 1830 and 1860 German and French scientists showed that different fermentations were caused by living organisms, and among these was the yeast organism, or, as it is commonly called, the yeast plant. Yeasts are also active in a number of other fermentations, viz., the brewing of beers, ales and wines, either commercial or home-made, the making of vinegar, the "spoiling" of canned fruit, and production of gassy curd in cheesemaking, etc.

Yeast plants are always microscopic, no species being large enough to be seen with the naked eye. The individual yeast plants average only 1-3000 of an inch in diameter, hence to see them at all requires a very powerful microscope. Yeast as seen with the naked eye, in a yeast cake or otherwise, is made up of a mass of millions of individual yeast cells or plants. If a bit of yeast is mixed with water, and examined under a high-power lens, there will be seen great numbers of cells such as shown in Fig. 7, some nearly spherical, some oval, and some even quite elongated. They are colourless as seen under the microscope, although in masses they appear of a creamy white colour. The outline or cell wall is regularly and sharply defined. The contents of the cell usually shows one and sometimes two or more rounded clear spots, called vacuoles, and a number of small fat drops besides the slightly granular protoplasm which makes up the remainder of the cell contents.

When a bit of yeast is placed in a solution which contains the proper food, the yeast cells immediately begin to consume the food and grow and multiply by the method known as budding. Upon the side of the cell appears a small swelling or bud. This little bud increases in size until finally it becomes as large as the original cell, when it in turn may begin to bud. This budding continues until there are produced large irregular shaped groups. (Fig. 7.) Later these groups may be broken up and the cells go into a sort of resting stage, each cell remaining by itself. Each of these single cells is capable of growth and multiplication by budding as soon as it is placed in any material that furnishes the proper food for its development. Hence yeasts may be likened to other plants the seeds of which require, among other things, a favourable soil in which to germinate and reproduce the plant.

The most favourable food for the common species of yeasts is sugar, and they will not grow rapidly unless sugar is present in considerable amounts. Bread dough ferments because it contains some sugar. Flour itself contains a large percentage of starch, part of which is changed to sugar, which is then fermented by the yeast present, with the result that there are formed two main products, alcohol and carbonic acid gas. It is the latter product that makes the sponge "raise." When the dough is baked, the alcohol is evaporated by the heat and the gas is expanded, making the loaf still larger and "lighter." Other chemical products

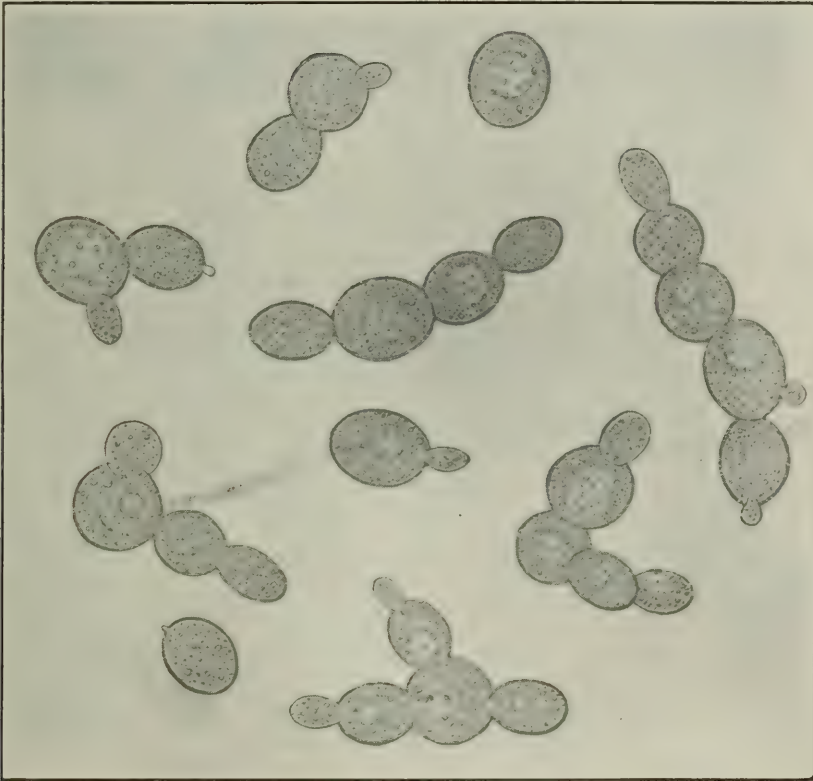


Fig. 7. Yeast cells. Highly magnified. (Sedgwick and Wilson.)

than alcohol and carbonic acid gas are formed in small amounts during the fermentation, and these have some influence in determining the flavour of the bread.

It has been shown that suitable food is essential for favourable growth of yeast. Another essential for the most rapid growth is a favourable temperature, and this factor is one of extreme importance in successful breadmaking. The best temperature for different species of yeasts varies with the species, but the average is about 80° F., or a little below blood heat. At low temperature the growth of the yeast is

checked, and, consequently, fermentation does not proceed so rapidly. Cold temperatures do not kill the yeast, and when a favourable temperature is again furnished, growth proceeds as before. At temperatures above 100° F., or body heat, the vitality of the yeast is weakened proportionately as the temperature increases, until at the boiling point it is entirely destroyed.

Although yeast is not killed or injured by low temperatures, yet, there is a disadvantage in allowing the temperature to get too low in preparing the sponge for bread. Flour frequently contains other organisms than yeasts (bacteria and molds), some of which are able to grow rapidly in the dough at temperatures lower than the optimum for yeasts, and form products which impart an undesirable flavour to the bread. Even the commercial yeasts may contain such undesirable organisms.

The two types of trouble most commonly met with are sour bread and slimy bread.

Dough may sometimes appear to rise well, but after the bread is baked it is found to have an unpleasant sour taste. This is due to the development in the dough before baking of acids produced in the growth of bacteria which were present in the flour, in old, or impure yeast, or in unclean utensils used in the process.

In the case of slimy bread, the sliminess is not usually apparent when the bread is freshly baked, but appears in a few hours, caused by the growth of bacteria that were not killed in the baking process. These slime-producing bacteria may arise from the same sources as the acid-producing bacteria. The remedy in either case is to use clean high-grade flour, fresh, pure yeast, and to see that all utensils are scrupulously clean. In addition to these precautions, it should be remembered that correct temperature is most essential for the normal development of yeast.

Other Methods of Leavening Bread.

Many attempts have been made to prepare materials that will replace yeast in breadmaking. It is evident that if a compound or mixture of compounds could be prepared that would give off carbon dioxide regularly, it might take the place of yeast as a leavening material. But nothing has been devised that has proved a success. Baking powders act well for biscuits and such work, but they have not given good results in the large mass of dough prepared in breadmaking. The "self rising" flour sometimes advertised is really flour mixed with materials of this nature. The chief objection to the use of any of these yeast substitutes is that they may be inefficient or harmful; that they are easily adulterated, and that the bread made from them is lacking in the flavour and aroma good yeast fermentation produces.

In some places "ærated bread" is made. The details of the process are kept more or less secret, but the dough is made to "rise" by means of carbon dioxide injected into the dough in various ways. Sometimes

a little fermented barley infusion from a brewery is put into the water used in making the dough. This appears to render the gluten more elastic and imparts some of the same flavor resulting from yeast fermentation.

The leavening of "salt rising" bread is dependent upon ferments originally present or acquired from the air. A common method of making it is to prepare a slack batter of milk and flour and allow it to stand at a temperature of about 100° F., until the ferments permeate the whole mass, or until it becomes sour. This is then mixed with a sponge prepared with hot water and flour, to which a little salt has been added. After thoroughly kneading the batter and the sponge together, it is put away in a warm place and the leavening action started in the batter spreads through the whole mass and produces a light, porous loaf of bread. It is an illustration of a self-raised bread, but as it is dependent upon the natural ferment content of the flour and the ferments that may get into it from the air, the method is uncertain.

SOME CHEMICAL CHANGES THAT TAKE PLACE IN THE PROCESS OF MAKING BREAD.

The object of making bread is to convert flour into a form in which it is convenient for use, palatable, nutritious and easily digested. This is accomplished by somewhat separating the particles of flour through the agency of yeast, by moulding the dough into shapes that are convenient to handle, and by baking it when in the raised condition so that the porous structure may be maintained, in order that when eaten the digestive juices of the body may readily penetrate the mass. Every step in the process of making bread produces changes in the composition of the raw materials, and the baker's success depends upon his ability to control these changes. Some of the more important changes are: (1) the change of insoluble carbohydrates into soluble forms; (2) the fermentation of sugars and the production of carbon dioxide and alcohol; (3) the formation of acids; (4) a change in the solubility of the proteid compounds; and (5) the volatilization or oxidation of some of the fat. These and many other changes take place, and, as some of the products are gases, a loss of materials must result.

The insoluble carbohydrates of flour are composed of starch and small quantities of other substances with which we are less familiar. The soluble forms, which do not exceed .3 to .5 per cent. of the flour, are made up of sugar and dextrin. The amount of the germ left in the flour influences the percentage of these soluble substances.

When the flour is made into a dough, diastase, a ferment native to the wheat, probably changes some starch into dextrins and sugars; the acids formed during the fermentation process and the heat of the oven will also account for the formation of some of these soluble compounds. According to Snyder, not more than 6 or 8 per cent. of the insoluble car-

bohydrates originally present in the flour are changed in this way, (1). But in addition to these chemical changes, the combined actions involved in the breadmaking process change the physical appearance of the starch cells. Some of them are partially disintegrated, while others are ruptured, thus rendering them more susceptible to the action of the digestive juices.

During the process of fermentation, the yeast changes some of the sugar of the dough into carbon dioxide and alcohol. The free escape of the carbon dioxide gas is prevented by the tenacity of the gluten, and thus it causes the dough to rise. The volatilization of the alcohol by the heat of the oven probably aids in the expansion of the dough; but, apparently most of the alcohol is changed to other compounds, as very little of it can be recovered from the oven and none of it is left in the bread.

Along with the alcohol fermentation, there is also some acid fermentation taking place. The extent of this action probably depends on the purity of the yeast, the temperature of the dough, and the length of time the fermentation is allowed to proceed. The result, of course, of too much acid fermentation is the production of sour bread. The acid, however, does not all remain in the free state, for some of it combines with the insoluble proteids, producing soluble forms. If this action proceeds far enough it may materially alter the size of the loaf by destroying the gluten, and it darkens the colour of the bread. It has been frequently noticed that some flours require a longer period of fermentation than others. Snyder states that probably this is due to the fact that gliadin, the gluey part of the gluten, is more readily acted upon by the acid than the glutenin, and that in these flours the prolonged fermentation causes the acid to dissolve more of the gliadin and thus bring these two constituents into the proper relationship to give the best results.

The influence of breadmaking on the fat has not been fully studied, but it appears to be changed in some way, for not more than about one-half of the fat in the flour can be extracted from the bread made from it. Evidently there has been some change affecting the composition of the fat which has changed its solubility.

The total loss of material in making bread by other than mechanical means has been stated by different investigators to vary from 1.5 to 6 per cent. The loss is made up principally of the volatile products of carbon and nitrogen. One investigator states that "in good breadmaking the losses are equivalent to about 3 pounds per barrel of flour, while with poor breadmaking the losses may exceed 12 pounds per barrel."

INFLUENCE OF TEMPERATURE.

In the yeast discussion, page 15, it was pointed out that one of the most important essentials for the rapid growth of yeast germs was a

(1) Bulletin No. 67, Office of Experiment Station, Dept. of Agriculture. Washington, D.C.

favourable temperature, and the temperature recommended was 80° F. This means that to secure the best results the dough should be kept at about this temperature during the time the yeast is working. A low temperature—about 70° F.—will suffice when the long fermentation process is allowed, *i. e.*, when the dough is allowed to rise over night. The difficulty in many households is to properly control the temperature. Frequently the dough is made without any definite determination of the temperature of the materials, and it is placed to “rise” where it is *hoped* the conditions will be satisfactory. The commercial baker does not take any such risks. He determines the temperature of the flour and then makes the water warm enough to raise the whole dough mass to the desired point, and then seeks to control the temperature during the fermentation period. He recognizes that temperature is one of the factors he must control in order that he may get uniform results.

Some years ago butter was made without the use of a thermometer; but, butter makers in the home and factory have long since recognized that they cannot depend upon “feel” to get the correct conditions. There is the same need of the thermometer in breadmaking, and when the breadmaker brings the dough to at least approximately the right temperature to start with, and places the dough to rise where the temperature can be controlled, a great advance will be made in the making of bread in the home. The difficulty has always been that the home breadmaker has no means of controlling the temperature, and has been forced to cover the dough and allow it to stand over or beside a radiator, register, or stove, and trust to luck that the temperature required would be maintained. It may become too hot or too cold, but it would not be known, unless the baker has sufficient experience to tell from the appearance and feel of the dough, and “luck” is blamed for the failure.

Dough will recover from a very severe chilling if it is brought back to the proper temperature and is allowed to stand long enough to rise properly. Chilling does not destroy the yeast germs, but it retards their development, and time must be given them to do their work. An experienced baker has an advantage over an inexperienced one in knowing when the dough has risen sufficiently. Too high temperature may destroy the germs altogether and thus prevent the dough rising.

A simple cabinet for controlling temperature during the dough stage has been devised by the Household Economics Department of this College. The cabinet is illustrated in Fig. 8. It is 2 feet 8 inches high, by 2 feet 2 inches broad, by 2 feet deep, outside measurements. The whole is lined with asbestos, and divided into upper and lower compartments. The partition is placed high enough to allow a small coal oil lamp to be placed in the bottom compartment. The lamp is used as the source of heat, and the heat is transmitted through water contained in a shallow covered galvanized iron pan placed in the centre of the partition. The fumes from the lamp are allowed to escape through small holes in the wooden frame below the partition. The

top compartment may be used with or without slatted shelves, and may be kept at any desired temperature by raising or lowering the flame of the lamp, thus influencing the temperature of the water, and consequently, that of the compartment. A very small lamp with the wick turned as low as possible is usually sufficient to maintain the temperature at from 70° to 80° F. It is hardly necessary to say that the thermometer should be left in the cabinet and the temperature noted from time to time, and the flame of the lamp so regulated as to give a constant desired temperature.

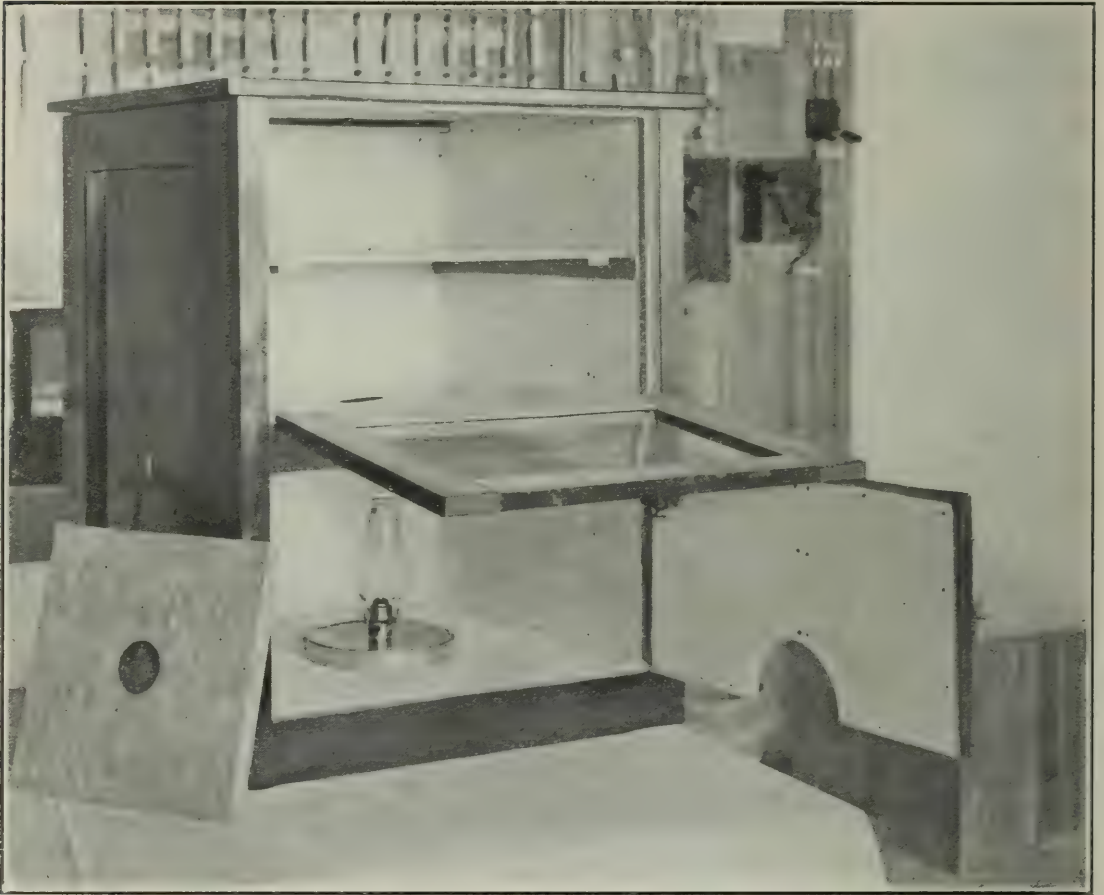


Fig. 8. Cabinet for controlling temperature in bread-making, showing shallow watertank standing at one side.

The cabinet may be made any desired size, and may be so arranged that the top will answer as a kneading board, and pans and other utensils may be kept in it between baking days.

Fig. 9 shows a simple form of cabinet made out of a packing box. The inside is lined with builder's asbestos paper and arranged very much as the one shown in Fig. 8.

By the use of such a cabinet it is possible to maintain the dough throughout the fermentation period at any desired temperature, and

thus render it possible to control one of the main sources of worry and uncertainty in breadmaking.

The asbestos is used to reduce the danger of the case taking fire if anything happened to the lamp, and also to check any draft through the cracks of the box. If the box is tight, and the danger from the lamp overlooked, there would be no necessity for lining the box.

METHODS OF MAKING BREAD.

There are various methods of making bread in the home. A few of the methods and their uses are discussed below.

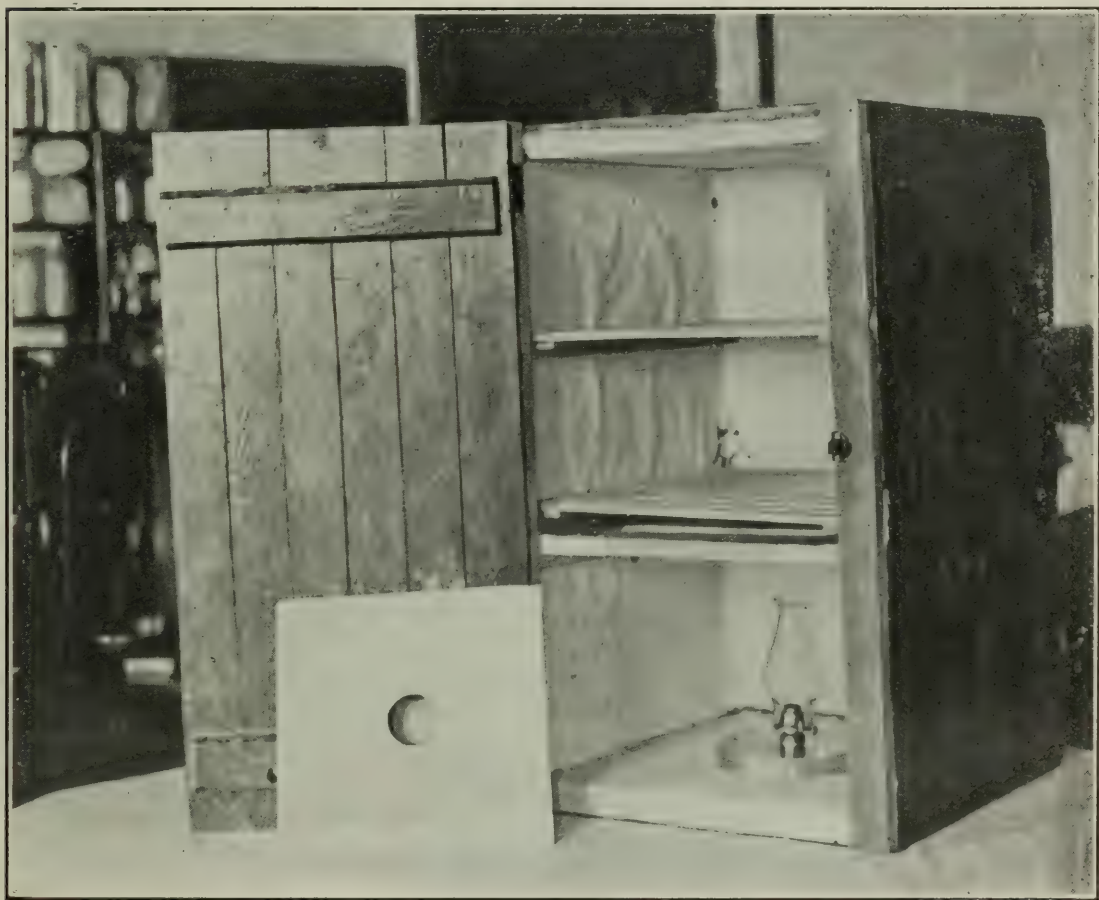


Fig. 9. Cabinet for controlling temperature in bread-making made out of packing-box.

1. *The ferment, sponge and dough method* is one of the most common methods in use, consisting of a ferment, sponge and dough stage. (a) *Ferment*: A thin batter made up of potato or plain water, a little sugar, and enough flour to make a pour batter, placed in a temperature of from 70 to 80° F., until it is light and spongy. This method is best suited to the use of dry compressed yeast, which is in a dry, dormant state, and needs the food, moisture, and warmth to bring it

into a healthy, vigorous ferment. (b) *Sponge*: At the stage the sugar, salt, shortening and sufficient liquid to make the desired amount of bread is added to the ferment, and flour added to make a thick batter, and this sponge is allowed to rise from 8 to 10 hours. (c) *Dough*. The dough is then made by the addition of all the flour needed to make the mass of the desired consistency.

2. *Sponge and dough*, probably the most widely used in the home, and the best adapted to the uses of the soft and hard flours. *Sponge* may be made with hard Manitoba flour and fermented from 6 to 10 hours. The hard flours take a much longer time to ripen, hence the reason for giving them the longer time in the sponge. Potato water and a little mashed potato improves this sponge. This is a desirable method where the home-made yeast is used, or the moist compressed yeast. The dough is made from this sponge with either hard or soft flour, either giving good results when properly used. The soft flour gives a loaf of very close texture, but a characteristic sweet flavour that is very much liked by some people, and can only be obtained where Ontario winter wheat flour is used.

3. *Offhand dough* is that method in which the dough is made direct without any preceding stages of ferment and sponge, and it is the best method to use when it is desirable to make bread in a short time. Because of the short fermentation period, it is necessary to use a much larger amount of yeast in proportion to the amount of liquid, and flavour must to some extent be sacrificed, but, if rightly manipulated, this method makes very nice bread and one in which a good grade of soft flour may be used. It is also a good method to follow in winter when there is no means of controlling temperature. The following recipes, typical of each process, are used in our flour testing laboratories with satisfactory results.

The beginner is advised to start with the first method and become thoroughly familiar with its successful use before proceeding to the others. She is also urged to use a thermometer in order to become sensitive to correct temperature as soon as possible. After these typical recipes are mastered the beginner should be able to follow the variations of any good cook book.

The following are the detailed directions for making bread by each of the above methods. When the recipe does not provide sufficient materials to make the desired quantity of bread, the amount of the various ingredients may be halved, doubled or changed in any way provided their relative proportion remains the same.

I. FERMENT. SPONGE AND DOUGH METHOD.

- 1 dry yeast cake.
- 2 quarts liquid.
- 2 level tablespoons salt.
- 2 level tablespoons sugar.
- 2 level tablespoons lard.
- Flour.

Preparation of Ferment. Put a pint of water at a temperature of about 90° F. into a bowl, drop the dry yeast cake into it and soak for half an hour, then stir in enough flour to make a thin batter, add one tablespoon sugar, and beat with a dover beater until well mixed and full of bubbles. Stand in a temperature of 70° to 80° F. until light, which will take from four to five hours.

Preparation of Sponge. When the ferment is ready, put the rest of the sugar, salt and lard into a kneading-pan, bring the rest of the liquid to 90° F. and add it to the ingredients in the pan. Add enough strong flour to make a batter that will beat without spattering; add the ferment and beat until it looks smooth and elastic. This will probably take 15 or 20 minutes. Cover closely, and keep at a temperature of 70° F., until light and spongy. This will take from 9 to 10 hours.

Preparation of Dough. When the sponge is ready stir in strong flour until too stiff to use the spoon, then mix in more with a stiff-bladed knife, or the hand, until the dough no longer sticks to the fingers. Turn the dough out on the moulding-board to knead, leaving the pan quite clean. The dough should knead without flour being put on the board or hands; if it proves sticky return it to the pan and mix in more flour, remembering that while too slack a dough makes coarse textured bread, too stiff a dough makes slow-rising bread which will dry out quickly. Knead lightly until the mass is elastic and velvety, the surface covered with a film of tiny bubbles, and a cut with a sharp knife shows the inside full of fine even bubbles and free from lumps or unmixed portions. Grease the kneading-pan lightly with lard, warm both pan and cover if they are cold, put in the dough, cover closely, and keep at a temperature of 80° F. until rather more than doubled in volume, or until a gentle slap with the tips of the fingers causes it to fall in. This will take from 2 to 3 hours.

Knead lightly in the pan for a minute to get rid of the larger bubbles and return to rise a second time until double in volume. This will take from 1 to 2 hours.

Divide into loaves that will half fill the bread tins. Knead each piece only enough to get rid of large bubbles and smooth the surface, and put it into a greased tin. Keep at a temperature of 70° to 80° F. until doubled in volume, when they should have a bold, nicely rounded appearance.

Bake an hour in an oven about 350° F. When done, the loaves should give a hollow sound when tapped on the bottom.

When baked remove at once from the pan, and stand on edge or across the top of the pans, that the air may get to all parts and cool it quickly.

VARIATIONS.

1. The above calls for strong flour. Soft flour may be used for the dough stage, but must be kneaded down before it has quite doubled

in volume each time. It is not advisable to use soft flour for the ferment and sponge stages, as it does not stand the long fermentation.

2. Home-made yeast may be used instead of the dry yeast. Use one cup home-made yeast and only $3\frac{1}{2}$ pints of liquid.

3. The liquid may be part milk (scalded) and part water. The latter may be potato water; *i.e.*, water in which two or three potatoes have been boiled, removed and finely mashed and returned to the liquid.

4. The potato water may form the liquid for the ferment stage, and the mashed potatoes added when the sponge is made. Potatoes give that silkyness of texture so much desired by good breadmakers.

5. If the dough is kept covered while rising it will not form a crust. If it seems inclined to form a crust, moisten it with warm milk and water. A crust is to be avoided as it makes a streak through the loaf if kneaded in at the early stage, and an unsightly crust on the baked loaf if allowed to form in the last stages.

6. The second rising of the dough may be omitted, although the extra rising makes the loaf a rather finer texture.

7. The bread-mixer may be used to knead the dough after it is known exactly how much flour the liquid will need to make dough of the right stiffness.

II. SPONGE AND DOUGH METHOD.

- 1 cake compressed yeast.
- 2 quarts liquid at 90° F.
- 2 level tablespoons salt.
- 2 level tablespoons sugar.
- 2 level tablespoons lard or butter.
- Flour.

Mix the yeast and half of the sugar in 1-4 cup of warm water, and let it stand at a temperature of 80° F. for 15 or 20 minutes to start fermentation.

Measure the shortening, salt, and rest of sugar, into kneading-pan, stir in the rest of the liquid, and mix in flour enough to beat without spattering. Then add the well-fermented yeast and beat with a wooden spoon until it looks smooth and elastic.

From this point treat just the same as in the ferment, sponge and dough method.

VARIATIONS.

1. The above calls for strong flour. Soft flour may be used for the dough stage, but must then be kneaded down before it has quite doubled in volume each time.

2. The second rising of the dough may be omitted, but the extra rising makes a loaf of rather finer texture. When a large batch is being

made, this may be taken advantage of to delay the baking of part until the first part is out of the oven.

3. The liquid may be all water, part water and part milk, or part potato-water and part milk.

4. Home-made yeast may replace the compressed yeast. Use one cup home-made yeast and only $3\frac{1}{2}$ pints liquid.

5. If the flour is taken from a cold place in the winter, it should be brought to a temperature of 80° F. before mixing it into either sponge or dough. When one has learned by experience what quantity of flour the liquid will take up, it is a good plan to measure the whole quantity into a kneading-pan, mix the sponge in another dish, make a well in the rest of the flour in the kneading-pan, pour in the sponge and stand the whole in a warm place to rise; then when the sponge is risen the rest of the flour can be kneaded in.

III. QUICK METHOD.

- $\frac{1}{2}$ cup milk.
- $\frac{3}{4}$ cup water.
- 1 cake compressed yeast.
- 1 teaspoon salt.
- 1 teaspoon sugar.
- 1 teaspoon lard or butter.
- Flour.

Put the sugar and yeast into a cup, add $\frac{1}{4}$ cup of the water warmed to 90° F., mix until the whole is smooth and the sugar dissolved, and stand in a temperature of 80° F. for 15 or 20 minutes to begin fermenting. Put the milk on to scald. Measure the salt and shortening into the kneading-pan, pour in the scalded milk, add the rest of the water and bring the temperature to about 90° F. Add strong flour enough at the same temperature to make a batter that will beat without spattering; add the yeast, now fermenting vigorously, and beat with a wooden spoon until it looks smooth and elastic. Mix in at once enough warm flour to make a dough that will not stick to the fingers, turn out on the moulding board and knead as usual. Return to the warm greased kneading-pan, cover closely and stand in a temperature of 70° to 80° F. until risen to rather more than double in volume. This will take 2 to 3 hours.

Knead lightly in the pan for a minute to get rid of the larger bubbles, and stand back in the warm place to rise again until double in volume. This will take 1 to 2 hours.

Shape into loaves that will half fill the bread tins, kneading only to get rid of large bubbles, and smooth the surface. Let rise until doubled in volume, then bake and cool as usual.

VARIATIONS:

1. Soft flours may be used for the whole process in this method, but care must be taken to knead it down at the proper time. It should be allowed to rise the first time to a little less than double in volume, and succeeding times still a little less. Once over-risen, soft flour dough is very hard to make into a good bread.

2. This process may be used for setting over night, using 1 cake of yeast to six times the quantity of all the other ingredients, and allowing it to rise 9 to 10 hours the first time. The longer time will develop a delicious flavour which can never be attained by the short process.

3. Home-made yeast may be used omitting the water. Bring the yeast to 80° F., add the sugar, and allow it to stand 10 to 20 minutes to begin working before adding it to the sponge.

HOME-MADE YEAST.

4 medium sized potatoes.
 $\frac{1}{2}$ cup hops.
 1 quart boiling water.
 $\frac{1}{2}$ cup sugar.
 1 cup flour.
 2 level tablespoons salt.
 1 compressed yeast cake.

Boil the potatoes, drain away the water, and mash the potatoes until free from lumps. Pour the boiling water, which may contain the water drained from the potatoes, over the hops and simmer 15 minutes. Measure into a three-quart bowl, or crock, the flour, sugar and salt, and mix them thoroughly. Strain the hop water, and add at once to the crock, stirring rapidly all the time. Add the mashed potatoes and give the whole a thorough beating. Cool to 70° or 80° F., and add one compressed yeast cake or one dry yeast cake soaked in $\frac{1}{2}$ cup of warm water for half an hour. Keep at a temperature of 70° F. for 3 or 4 hours, stirring down as often as it comes to the top. Bottle and keep in a cool place. Do not cork it tightly at first.

One cup of yeast is equal to one compressed or one dry yeast cake.

ROLLS.

1 $\frac{1}{2}$ cup milk.
 $\frac{1}{2}$ cup water.
 1 cake compressed yeast.
 2 level teaspoons salt.
 2 level tablespoons sugar.
 2 level tablespoons butter.
 1 level tablespoon lard.
 Flour.

Put the yeast cake and one tablespoonful of the sugar in a cup, add 1-4 cup of the water warmed to 90° F., mix until smooth and the sugar is dissolved, and stand in a temperature of 80° F. for 20 minutes. Put the milk on to scald. Measure the butter, lard, salt, and the rest of the sugar into a kneading-pan, pour in the scalding milk, add the remaining 1-4 cup of cold water, and allow it to come to 90° F.

Add enough flour to make a batter that will not spatter when beaten, stir in the fermenting yeast, and beat until it looks smooth and elastic.

Mix in enough more flour to make a dough that will not stick to the hands. Turn out on the board and knead until smooth, velvety and even textured. Return to the warm, greased bread-tin, cover closely, and keep at 80° F. until nearly tripled in volume.

Knead down in the pan, and let rise again at 80° F. until double in volume.

Shape into small rolls, remembering that they will increase greatly in size, put them into greased pans, and stand in a temperature of 80° F. until doubled in volume. Take care that the surface does not dry. If it is not possible to keep them covered closely, it will be necessary to moisten the top occasionally with warm milk or water.

Bake in a little hotter oven than used for bread for from 20 to 35 minutes, depending on the size of the rolls and the heat of the oven. The oven must not be too hot at first or it will prevent the expansion of the rolls, and may result in doughy centres.

Cool quickly by exposing as much surface as possible to the air.

SUMMARY.

The essentials of successful home breadmaking are:

1. Good bread flour.
2. Good yeast.
3. Dough of the right consistency.
4. Control of the temperature at all stages.
5. To remember that soft flour has not the expansive power of strong flour, and that soft flour doughs must never be allowed to rise longer than necessary. If it rises to the point of falling back, results will not be good.
6. To avoid drying out of the surface at all stages, as this makes a dark streak through the baked loaf.

MACDONALD INSTITUTE RECIPE FOR BAKING POWDER BISCUITS.

- 4 level cups flour.
- 1 level teaspoon salt.
- 2 level tablespoons shortening.
- 2½ level tablespoons baking powder.
- About 1½ cups milk.

The shortening may be sweet lard, or dripping, or butter, or a mixture.

See that the shortening is soft enough to rub easily. Place the board, mixing knife, rolling pin, cutter, and pan ready, and see that the oven is hot.

Sift the salt and flour into a bowl; rub the shortening into it with the fingers; sift in the baking powder, and mix well. Mix into a soft dough with the milk, using a broad-bladed, flexible knife, in order to cut and mix it quickly. Flour the board lightly, turn the dough out, and roll it round to coat it with flour. Knead just enough to make the dough smooth, roll out about an inch thick, and cut into small biscuits.

Place them in the pan, wet the tops only with milk or water, and bake in a hot oven about 20 minutes.

The secret of success is a slack dough, quick mixing, and little handling.

STRONG VS. WEAK FLOUR FOR BAKING POWDER BISCUITS.

It is the opinion of some bakers that the strong spring wheat flours are better for making baking powder biscuits than the softer and weaker flour from the winter wheats. The opposite view is just as strongly held by others. To secure definite data on this point some experimental work was done in the Macdonald Institute with six different kinds of flour, including both strong and soft flours and also blended flour. We quote from the report of the work given in the Ontario Agricultural Report for 1908:

"The flours used were obtained from the manufacturers for other purposes, but were regular brands, which might have been bought in the open market, and were chosen as likely to yield decisive information. They were:

"A. Strong—A high patent flour, made wholly of Manitoba wheat.

"B. Strong—A high patent flour, made wholly of Manitoba wheat.

"C. Soft—A nearly straight grade flour, made wholly of Ontario wheat.

"D. Blend—A combination of 20 per cent. B strong and 80 per cent. C soft.

"E. Soft—An 85 per cent. soft wheat flour, made wholly from Ontario wheat.

"F. Soft—A 35 per cent. soft wheat flour, made wholly from Ontario wheat.

"The Macdonald Institute recipe for milk biscuits was taken as the starting point, and a series of experiments carried out to determine various points before making the final test. In every baking each ingredient was carefully weighed, the biscuits compared with others, and results recorded to guide the procedure of the next experiment. When

rolling out the dough before cutting the biscuits flat sticks of equal thickness were laid on either side for the rolling-pin to travel on, so that the biscuits of all bakings were as nearly alike in thickness before baking as was possible with dough of such slackness. Only the biscuits cut from the first rolling were baked, so that no biscuits were made from dough that had been worked over."

Experimental bakings were made to determine what proportion of fat, baking powder, and what oven temperature would yield the best results. Experimental bakings were also made to determine the proportion of milk needed for each flour, in order to have each dough of the same slackness, the effect of doughs of different slackness, etc. Finally, making use of the experience gained with each flour, a concluding baking was made.

"The ingredients for each batch (except the milk) were weighed and kept carefully separate before any mixing was done. The mixing and baking were done as rapidly as possible. Nine biscuits of each flour were baked; when sufficiently cooled the best six of each were numbered and placed in a covered wooden box to prevent drying out before they were judged. The following table gives the weight of each ingredient used in making the biscuits and the weights recovered after baking.

Baking No.	Flour	Weight in grams of					Biscuits		Oven Temp. Fah.	Per cent loss in baking
		Flour	Butter	Bak. Pow.	Milk	Dough	Raw	Baked		
24.	A. Strong	300	24	16	252	592	308	257	450°	16
25.	B. "	300	24	16	248	588	307	257	450°	16
26.	C. Soft	300	24	16	212	552	323	260	450°	19
27.	D. Blend	300	24	16	221	561	306	259	430°	15
28.	E. 85% Soft	300	24	16	222	562	302	257	450°	14
29.	F. 35% "	300	24	16	218	558	295	247	450°	16

"When baked, these biscuits were much alike in general appearance, owing to the care taken in proportioning ingredients, maintaining oven temperature, and in manipulation; but the experimenter judged the first two about equal; C soft, rather better; 85 per cent. decidedly best, with 35 per cent. a close second.

"The Dominion Millers' district meeting was held in Guelph, December 12, 1907. One session was held in the O. A. C. Chemical Building, about twelve hours after the biscuits were finished. All the numbered biscuits were carried over, the meeting informed of the uniformity of manipulation, quantities of flour, fat, and baking powder, but not told the names of the flour or quantities of milk used, and the meeting asked to judge which were best. A committee of three was appointed, which reported Nos. 28 and 29 as best, but declined to rank one above the

other. The committee stated that there was so little difference between the other lots that judgment between them was very difficult.

*“Conclusion—*Soft wheat flours yield the tenderest biscuits when conditions are uniform.

*“Remarks.—*When strong and weak flours are made slack enough for biscuits, and both are of the same slackness, the difference in ‘handling’ quality is very noticeable. The strong flour dough has a stickiness like glue, while the soft flour has a silky smoothness, which is much easier to handle.

*“Summary.—*1. Other things being equal, soft wheat flours make more tender milk biscuits than strong wheat flour.

“2. Given a strong wheat flour dough and a soft wheat flour dough of equal slackness and suitable for milk biscuits, the soft wheat flour dough is the easier to handle.

“3. At the present prices of the different flours the strong wheat flour biscuits cost more than soft wheat flour biscuits.

“4. It is possible that a larger proportion of fat used with the strong wheat flour would yield biscuits of tenderness equal to those of soft wheat flour, but the cost of fat makes that method of improvement a disadvantage.”

PASTRY.

The soft flours are generally used for making pastry, and are, consequently, called pastry flour. It does not follow, however, that good pastry cannot be made from the stronger flours. In fact, experiments made in Macdonald Institute have clearly shown that it is possible; but more shortening must be used to get results obtainable from the softer winter wheat flour. The greater gluten content, expansive powers, and good colour of the stronger flours are not necessary requisites for pastry purposes; and, consequently, it would not appear to be good practice to purchase these more expensive flours and then use larger quantities of shortening in order to obtain the same results that may be secured by the use of the cheaper flours and less shortening. Practically the matter resolves itself into one of cost.

SHORT PASTRY.

1 lb. flour.
 $\frac{1}{2}$ lb. shortening.
 Ice-cold water.

The shortening may be a mixture of butter and sweet lard or sweet dripping.

If the fingers are cool, the shortening may be rubbed into the flour; otherwise, it should be cut into it with two knives until thoroughly mixed with the flour.

Mix into a dough with the ice water, using only enough to hold it together. It should be so dry that it will not stick to the bowl anywhere.

Turn out on the floured board, and knead only enough to make the ball smooth, when it is ready to cut into pieces for rolling out to line pie-plates, etc.

The quantity of shortening may be lessened for a plainer pastry.

FLAKY PASTRY.

1 lb. flour.

$\frac{1}{2}$ to $\frac{3}{4}$ cup butter.

Ice-cold water.

Rub two ounces of the butter into the flour. Cut the remainder into half-inch dice, and stir through the flour. Mix the water in with a broad-bladed knife, using only enough to hold the flour and butter together in shreds. If the quantity is difficult to mix without cutting through the butter lumps, flour the board, lift out the part that mixes first, and proceed to mix the rest. The object is to avoid any further breaking of the butter lumps. Turn the mixture out on the board in a pile, pack it together with the hands, and roll out into a sheet. Use a broad-bladed knife, and fold it into three or four layers, tucking in all the loose shreds about the edges. Be sure it is not sticking to the board, turn it around, and roll out again. Fold and roll out again. Fold in half and set away to chill, if necessary, before rolling it out to line pie-plates, etc.

This requires a hot oven at first to puff it, but a cooler one to complete the baking.

PUFF PASTRY.

$\frac{1}{2}$ lb. flour.

$\frac{1}{2}$ lb. butter.

Ice-cold water.

Wash the butter, form it into a flat, round cake, and put it away to chill. Make the flour into a stiff dough with ice water, and knead until perfectly smooth. It should be firm enough to roll out without much contraction, but should not be dry. Roll into two pieces a trifle larger than the butter pat; place the butter on one, moisten the edge, place the other on top, and press the edges together. Put aside to chill. Roll it out in one direction only, until about three times as long as broad, fold into three or four layers, turn around and roll again in the other direction, then set aside to chill. Roll and chill twice more in the same way, but fold it in half the last time. It is then ready to roll out and cut into shape for baking.

The oven for baking should be rather hot at first, then cooler, to permit of baking the pastry thoroughly without burning. One-quarter of the butter may be replaced with lard.

The cook books indicate many different ways of making puff pastry, and all of them are good in skilful hands. Skill is attained only through practice and the judgment of experience.

It would seem important to exercise care, as follows:

1. To make the dough of just the right consistency.
2. To prevent any softening of the butter during the rolling operations. If the maker can work in a temperature just above freezing, no special chilling is necessary.
3. To roll lightly, but evenly, to avoid crushing layers together.
4. To regulate the oven carefully to secure the strong heat necessary to puffing the layers and yet avoid burning.

COMPOSITION OF BREAD MADE FROM DIFFERENT KINDS OF FLOUR.

It has been pointed out that many changes take place during the process of breadmaking; but while these changes affect the composition of the various groups of materials, as the proteids and carbohydrates, they do not materially alter their proportion to one another. The increased percentage of water in the bread naturally decreases the percentage of other constituents from what they were in the flour. The following table gives the average results of a number of analyses of bread made from different grades and different kinds of flour. All the breads analyzed, with the exception of that marked baker's bread, were made in our own flour-testing laboratory.

COMPOSITION OF BREAD.

Kind of Flour	Moisture	Protein	Fat	Ash	Soluble Carbohydrates
Patent	36.80	7.60	1.80	1.25	52.53
Baker's grade	36.84	7.82	1.71	1.32	52.30
Standard patent 85%	37.40	7.74	1.71	1.27	51.88
Bakers' bread	38.02	8.23	.43	1.13	51.63
Home-made					
Spring wheat	37.24	9.28	1.54	.92	51.04
Home-made					
Winter wheat	33.31	6.17	2.54	1.06	56.91

The strong flours always absorb the most water, consequently a greater weight of bread can be made from them than from the softer and weaker flours. Notice the low moisture content of the home-made bread from soft winter wheat, as compared with the same kind of bread made from spring wheat. With very low grade flour of the red dog type the water absorptive power is greater than it is in the better flours, but the loaf of bread produced is not marketable.

Some of the bakers' bread and the home-made bread from spring wheat were made with flour from wheat grown in the season of 1909. This accounts for the high percentage of proteids, as the wheat of the 1908 crop was much lower in this constituent. Incidentally, it may be mentioned that because of this increased proteid content and, consequently, gluten content, the flour from this year's crop of wheat is very much superior to that of last year. Naturally, the bread from the soft winter wheat is low in proteid, as the flour and wheat it is made from are low in this constituent.

The low fat content of the baker's bread is due to the fact that no lard or other fat materials were added to this bread. In all other cases some lard was used. The home-made bread from the winter wheat flour evidently contains the most fat, but this cannot be credited to the flour. It is due to larger amounts of lard being added in the process of making the bread. The high soluble carbohydrate, or starch, content of the bread from winter wheat flour is naturally due to the comparatively low percentage amounts of protein and water.

It is evident that there is not much difference in the composition of the ordinary bread made from the higher grades of the spring wheat flours, but there is considerable difference when we compare this bread with that made from the winter wheat flour. We are frequently asked which of these breads actually furnishes the most nourishment to the body. To answer this question we made bread from four kinds of flour and analyzed it. The flours used in the work were the patent and bakers' grades, from Manitoba spring wheat, an 85 per cent. or standard patent, from the same grade of wheat, and 85 per cent. from all Ontario soft winter wheat. The bread was made in the regular way in our flour-testing laboratory—in fact, the loaves were taken from some of the regular testing work. In this work we used 12 ounces of flour for a loaf, and each lot of flour received exactly the same amount of yeast, salt, etc., and all the water it would absorb. The bread was weighed, dried, and the whole mass ground to an impalpable powder and analyzed. The average results of a number of analyses are given in the following table. As the actual size of the loaves, their colour, texture, etc., do not enter into the problem, these data have been omitted. It may be stated, however, that the bread was all of a good quality. Naturally, the loaves from the Ontario flour were not so large, but the bread was a fair sample of that got from these flours.

PERCENTAGE COMPOSITION OF THE BREAD.

	Av. wt. of loaf *grams	Water	Protein	Fat	Carbo- hydrates	Ash
Patent	502	36.48	7.29	1.76	53.42	1.05
Bakers'	506	36.75	7.39	1.71	52.81	1.32
85% Manitoba	501	36.10	7.93	1.73	52.92	1.33
85% Ontario	468	32.90	5.74	1.63	58.58	1.15

*28.34 grams in 1 ounce.

It will be seen from the above table that the various spring wheat flours produced about an equal weight of bread which was very similar in composition, while the Ontario winter wheat flour gave less bread with a lower water, protein, and fat content, and a considerably greater amount of carbohydrates. This is as expected, as the soft flour is starchy and poor in protein.

In order that we may make a closer comparison of the amounts of the various food constituents furnished by each 12 ounces of flour, the weights of protein, fat and carbohydrates contained in each loaf were calculated and are given in the following table. The fuel, or calorimeter value of each loaf was also calculated and is given in the last column of the table.

WEIGHT IN GRAMS OF FOOD CONSTITUENTS AND FUEL VALUE OF EACH LOAF OF BREAD.

	Protein	Fat	Carbo- hydrates	Ash	Fuel value
Patent	36.60	8.84	268.17	5.27	1399.
Bakers'	37.39	8.65	267.22	6.68	1393.
85% Manitoba	39.73	8.67	265.13	6.66	1388.
85% Ontario	26.91	7.63	274.15	5.38	1351.

It is generally assumed that, provided any given food is consumed as part of a well-balanced dietary, the number of calories of heat it will produce when burned, or, in other words, its fuel value, is the best basis for making a comparison of the nutritive value. Taking this as the basis, we have the figures given in the last column.

It will thus be seen that the soft wheat flour gave bread that contained approximately one-third less protein, or flesh-forming material, a little less fat, but more carbohydrates, and that it would furnish only 3.5 per cent. less energy than the bread from the spring wheat flour.

From these figures we must conclude that, when eaten in the usual way as part of a mixed diet, bread from the soft wheat flour is practically equal in nutritive value to that obtained from the hard spring wheats.

NUTRITIVE VALUE OF WHITE AND BROWN BREAD.

The comparative nutritive value of white and brown bread has always been a subject of controversy. The theory is advanced that in preparing the finer flours much of the most nourishing of the food materials are removed, and, consequently, the whole wheat, or Graham flour, is the most nutritious and healthful. In studying the nutritive value of any food it must always be borne in mind that it is not the flour or bread that contains the highest percentage of the most valuable food constituents that is the most nourishing, but it is the one that contains the most of these constituents in a form that is capable of being absorbed. The coarser flours have a higher percentage of protein, fat, and mineral matters than the finer grades, and so has bran; but, owing to the amount of crude fibre, or cellulose, surrounding these materials, they are not so well assimilated, and they really furnish less nourishment than is obtained from the bread made from the finer grades of flour. The work of Snyder, of Minnesota, Wood and Merrill, of Maine, and others, have clearly shown this. A few figures taken from Bulletin No. 101 of the Office of Experiment Stations, Department of Agriculture, will illustrate the point.

In the work referred to the different grades of flour experimented with were made from one stream of wheat, the flours and the bread made from them were analyzed, and the digestibility of the bread determined. We shall only refer to three grades of flour—*i. e.*, the standard patent, or straight grade, which represented about 96 per cent. of the total flour from the wheat; the entire wheat flour, which is made by removing part of the outer bran layers and then grinding, and a true whole wheat or Graham flour, *i. e.*, a flour made from the clean, scoured wheat without any bolting process. The composition of these three kinds of flours was found to be as follows:

COMPOSITION AND HEAT OF COMBUSTION OF THE FLOURS.

	Water %	Pro- tein %	Fat %	Carbo- hydrates %	Ash %	Phos- phoric acid %	Heat of combustion	
							Calculated calories	Determin'd calories
Standard patent or Straight	10.54	11.99	1.61	75.36	.50	.20	4.022	4.050
Entire wheat	10.81	12.26	2.24	73.67	1.02	.54	4.026	4.032
flour	8.61	12.65	2.44	74.58	1.72	.71	4.123	4.148
Graham flour								

No crude fibre is given in the above table, but it would increase as we pass from the finer to the coarser flours. The percentage of protein and fat also increases, but the carbohydrates decrease, and the difference here would be still more pronounced had the crude fibre been separated.

When the bread made from these three flours was submitted to digestion experiments the following results were obtained:

DIGESTIBILITY OF NUTRIENTS AND AVAILABILITY OF ENERGY OF BREAD.

	Protein %	Fat %	Carbohydrates %	Energy %
White Bread	85.8	56.4	97.5	90.1
Entire-wheat bread	80.4	55.8	94.1	85.5
Graham Bread	77.6	58.0	88.4	80.7

This means that in these experiments 85.8 per cent. of the protein in the bread from the straight grade flour was digested and only 77.6 per cent. of that in the Graham bread. Furthermore, while 90.1 per cent. of the total fuel or energy value of the white bread was available, only 80.7 per cent. of the total energy of the Graham flour was of use to the person eating the bread.

The same bulletin shows that the bread from the first patent, which represents about 35 per cent. of the finest of the flour, is even more digestible than that from the straight grade flour.

In 1857 Laws and Gilbert, of the Rothamsted Institution, England,¹ studied this same question; and, in view of the fact that the roller process of making flour was not then in use, their conclusions will be of interest. Writing in 1881, Gilbert summarized their conclusions as follows:² "The higher percentage of nitrogen in bran than in fine flour has frequently led to the recommendation of the coarser breads as more nutritious than the finer. We have already seen that the more branny portions of the grain also contain a much larger percentage of mineral matter. . . . It is, however, we think, very questionable whether upon such data alone a valid opinion can be formed of the comparative values as food of bread made from the finer or coarser flours from one and the same grain. . . . Again, it is an indisputable fact that branny particles, when admitted into the flour in the degree of imperfect division in which our ordinary milling processes leave them, very considerably increase the peristaltic action, and hence the alimentary canal is cleared much more rapidly of its contents. It is also well known that the poorer classes almost invariably prefer the whiter bread; and among

¹Rothamsted Memoirs, Vol. 1.

²Rothamsted Memoirs, Vol. 5.

some of them who work the hardest and who, consequently, would soonest appreciate a difference in nutritive quality (navvies, for example), it is distinctly stated that their preference for whiter bread is founded on the fact that the browner breads pass through them too rapidly; consequently, before their systems have extracted from it as much nutritious matter as it ought to yield them. It is freely granted that much useful nutritious matter is, in the first instance, lost as human food in the abandonment of 15 to 20 per cent. of the wheat grain to the lower animals. It should be remembered, however, that the amount of food so applied is by no means entirely wasted. And, further, we think it more than doubtful, even admitting that an increased proportion of mineral and nitrogenous constituents would be an advantage, whether, unless the branny particles could be either excluded or so reduced as to prevent the clearing action above alluded to, more nutriment would not be lost to the system by this action than would be gained by the introduction into the body, coincidentally with it, of a larger actual amount of supposed nutritious matter. In fact, all experience tends to show that the state, as well as the chemical composition of our food, must be considered; in other words, that its digestibility and aptitude for assimilation, are not less important qualities than its ultimate composition.

“Of course, if the branny particles were reduced to a perfect state of fineness, and it were found that this prevented the aperient action, and that other evils were not introduced; or, better still, if more of the food materials can be separated from the bran, and in either case without more cost than the saving would be worth, there might be some advantage. But to suppose that whole wheat meal as ordinarily prepared is, as has generally been assumed, weight for weight, more nutritious than ordinary bread flour is an utter fallacy, founded on theoretical text-book data, not only entirely unsupported by experience, but inconsistent with it. In fact, it is just the poorer fed and the harder working who should have the ordinary flour bread rather than the whole-meal bread as hitherto prepared, and it is the overfed and the sedentary who should have such whole-meal bread. Lastly, if whole grain were finely ground, it is by no means certain that the percentage of real nutritive nitrogenous matters would be higher than in ordinary bread-flour, and it is quite a question whether the excess of earthy phosphates would not then be injurious.”

The previously presented results on the digestibility of different kinds of bread confirm the above conclusions of Laws and Gilbert. In concluding the discussions on the nutritive value of bread, we submit the conclusions of a study of the composition and digestibility of white and whole-wheat bread given in the St. Bartholomew's Hospital Report. London, England, 1897:

“From the experiments we are justified in concluding that the higher nutritive value which we might, upon pure chemical grounds, ascribe to

brown bread, cannot, with the single exception of fats and mineral constituents, be maintained from the physiological side. On the other hand, distinctly less nutritive materials actually get into the blood in the case of the brown than of the white bread. . . .

"White bread is, weight for weight, more nutritious than brown. Therefore, it appears the preference given by operators in large towns for white bread has to a certain extent a sound physiological basis.

"In the case of people with irritable intestines white bread is to be preferred to brown.

"In the case of people with sluggish intestines brown bread is preferable to white, as it tends to maintain regular peristaltic action and ensure regular evacuation of the bowels, with all its attendant advantages,

"In cases where the proportion of mineral ingredients, and especially of lime salts, in other articles of food or drink is insufficient, brown bread is preferable to white. . . .

"If the dietary is insufficient in fat, or if the patient is unable to readily digest fat in other forms, brown bread may possibly be preferable to white."

In this country, where everyone eats a very varied diet, it is doubtful if a sufficiency of ash materials and fat are not taken into the system without using the bread from the coarser flour for the purpose of obtaining these substances. Moreover, it is evident that the comparative nutritive value of white and brown bread varies with the individual.

COMPARISON OF THE NUTRITIVE VALUE OF BREAD AND SOME OF THE COMMON FOODS.

Bread is often referred to as the "staff of life," presumably because it is so universally used, and because it is one of our cheapest foods, and, at the same time, very nutritious and palatable. It is sometimes spoken of as a complete food, *i. e.*, one that furnishes all the nutrients required to nourish the body and in the proper proportion. It possibly fails somewhat in the latter respect; but, as is well known, the food of man must please the palate as well as satisfy the demands of the body, and to do this we must have a varied and mixed diet. This is not the place to discuss the balancing or cost of diets; but, for purposes of comparison, it may not be out of place to show the amounts of the important food constituents furnished by other common foods. For this purpose we have calculated the weight of protein, fat, and carbohydrates, and the number of calories of heat one dollar's worth of each of the more common foods will furnish. The figures are based on the average composition of the foods as purchased.

WEIGHT OF PROTEIN, FAT, AND CARBOHYDRATES, AND THE FUEL VALUE
OF \$1.00 WORTH OF EACH FOOD.

	Price per lb.	Refuse %	Protein lbs.	Fat lbs.	Carbo- hydrates lbs.	Fuel Value cal.
Milk	6c. quart	—	1.38	1.69	2.21	13,009
Milk	8c. quart	—	1.04	1.27	1.66	10,402
Skimmed milk	10c. gallon	—	3.4	.30	5.1	17,070
Buttermilk	10c. gallon	—	3.0	.50	4.8	17,362
Butter	25c. pound	—	0.04	3.4	—	14,422
Cheese	17c. "	—	1.63	2.16	.24	12,593
Beef, fore quarter (wholesale)	6c. "	18.7	2.41	2.91	—	16,762
Beef, hind quarter (wholesale)	8c. "	15.7	1.92	2.29	—	13,235
Beef, flank	8c. "	10.2	2.12	2.37	—	13,944
Beef, sirloin	18c. "	12.8	.92	.90	—	5,509
Veal, cutlets	15c. "	3.4	1.34	.50	—	4,612
Mutton, chops	16c. "	16.0	.84	1.80	—	9,158
Lamb, hind quarter	18c. "	15.7	.92	.90	—	5,509
Ham, smoked	18c. "	13.6	.79	1.85	—	9,276
Ham, smoked and cooked	30c. "	—	.67	.75	—	4,405
Eggs	25c. dozen	11.2	.79	.56	—	3,853
White bread	2½ lbs. 10c.	—	2.10	.5	12.2	28,710
Rolled oats	7 lbs. 25c.	—	3.5	1.9	20.0	51,730
Farinas	6 lbs. 25c.	—	2.3	.24	18.7	40,070
Potatoes	90c. bag	20.0	2.18	.10	15.6	33,492

In some respects the figures are hardly fair, as some of the foods have to be cooked, whereas the bread is ready for use. If the weight of protein, fat, and carbohydrates furnished by one dollar's worth of flour had been given, they would have been about double that furnished by bread, and much larger than that supplied by oatmeal. However, as the figures stand, it is evident that bread is one of our cheapest foods, and when we take into consideration its palatability and high digestibility, it may well be termed the "staff of life."

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